THE

ELECTRICAL REVIEW.

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PROGRESS IN SUBMARINE TELEGRAPHY.

THE development of submarine telegraphy, which has been rather shelved of late years, owing in part no doubt to the absorbing interest which has in turn attached to telephony, electric light, electric traction, and other competing claims to attention, seems to be forcing its way again to the fore. The advantages of an agent which annihilates space, and brings the remotest parts of the world within speaking distance, is second in importance to no other branch of applied science, and as was to be expected, inter-communication between distant countries and commerce, promoted by telegraphy, have created a demand for increased speed which the present means of signalling through very long cables are inadequate to meet.

To the growing desire for federation, and the necessity for the most direct cable communication between Great Britain and her Colonies, may be largely attributed this fresh impulse in the direction of progress, because it is the exceptional obstacles which very long cables—such as those which it is proposed to lay between Canada and Australia—present to signalling, which has again started electrical scientists thinking.

As in the commercial world the demand regulates the supply, so there is little doubt that our cable experts, who are becoming fully alive to the importance of the subject, and have of late been attacking the problem afresh, will, as in the past, prove equal to the occasion.

When Atlantic cables became unequal to the increasing traffic, duplex telegraphy relieved the pressure by doubling their carrying capacity.

Notwithstanding the additional cables laid, it has of late however, been found necessary to more than double the weight of the conductor to increase the working speed of 45—50 words per minute, instead of some 25 words carried by the earlier and lighter types.

Not only has the rate of transmission been accelerated by the mathematical precision of automatic transmitters, but a further increase in speed of 35 to 40 per cent. is said to have been achieved on some of the Eastern Company's cables by means of the Muirhead curb transmitter.

To minimise delay in re-transmitting a message, apparatus has recently been devised by Messrs. Taylor & Dearlove to automatically translate messages from a landline, or cable, into a second cable; the translated signals being as well defined as those sent from the station of origin. A new and highly sensitive cable relay has, moreover, been recently patented for submarine work; and some improvement may no doubt be expected from more delicate receiving apparatus.

But in addition to these advances all along the line, we are encouraged to expect a further substantial increase in speed, which is especially required in the case of very long cables.

For instance:—Mr. Oliver Heaviside's mathematical calculations promise *double* the speed through an Atlantic cable

by means of "proper leaks" along the cable; or by the employment of an insulator having a dielectric resistance of about 1 megohm per knot, there still being enough current arriving at the distant end to work with.

Again:—Prof. Silvanus Thompson goes so far as to predict that a cable having two separately insulated conductors, connected by a high resistance leak at three points, would transmit signals four or five times as quickly as the best single core laid; while with five leaks it will transmit seven or eight times as quickly.

In another part of the Review will be found an exposition, by Messrs. Edwin J. Houston and A. E. Kennelly, of the modern theory of the transmission of signals through a submarine cable. The remarks bearing on a *distortionless circuit* come very opportunely at the present time, when so much attention is being drawn to the beneficial effect of leaks in accelerating speed.

Speaking of a so-called *distortionless circuit*, Messrs. Houston & Kennelly in the paper, a part of which we reproduce on page 548, say: "It is possible so to unite imperfect insulation with imperfect conduction, *i.e.*, leakage with conductor resistance, as to cause the tailings due to leakage to exactly annul the tailings due to conductor resistance. A circuit in which the leakage and conductor resistance are so balanced as to leave no tailings is called a *distortionless circuit*, and no other means of obtaining a distortionless circuit is known at the present time. Although such a circuit is distortionless, since no tailings are left, yet energy is expended both in the insulator and in the conductor, and consequently the fluxes diminish in density and attenuation goes on." "Not only the delay or retardation of the received signals, but also the great distortion which is noticeable, are due entirely to the fact that there is very little leakage in the insulator, while there is very appreciable resistance in the conductor."

With reference to the Anglo-American cable laid in 1894, we are told that "if the insulation, instead of being 85,000,000,000 (*sic*) ohms per N.M., were reduced to 500 ohms per N.M., the leakage tailings would probably balance the tailings due to imperfect conductance, and the cable would be distortionless. The signals received would, therefore, be the exact counterpart of the signals sent, and an indefinitely high speed of signalling should be possible. In respect to absence from distortion, such an Atlantic cable would transmit telephonic speech waves perfectly.

It would, however, possess so much leakage that the received signals would be far too attenuated and feeble to perceive. The conductor would only offer at the sending end a resistance of approximately 28 ohms instead of 3,108 ohms—the total conductor resistance—and the current strength which would flow from the receiving end to ground would be approximately 5×10^{47} times less than the current entering at the generating end. No telegraphic or telephonic instrument at the present time could detect so feeble a current. Moreover, if any accident happened to such a cable it would be impossible to localise the position of a fault, unless the same occurred within a mile or two of either end. Consequently the *distortionless circuit* does not provide at the present time a practical solution for Trans-Atlantic telephony."

The difficulty of localising faults in cables having a very much higher insulation per N.M. than that referred to above has been pointed out in these columns, and no doubt it offers a very serious objection to leak resistances between parallel conductors, or even to uniformly low insulation resistance per N.M.; but, in view of the importance of the subject, it is to be hoped that experiments may be made to determine precisely what improvement in speed can be obtained in practice for different values of insulation per N.M. "Half a loaf is better than no bread," and we shall, at any rate, then know what increase in speed can be derived from a reasonable reduction of insulation resistance.

Unfortunately results with leaks on artificial lines, have, so far, not been very encouraging, since they show that for a given working current any increased definition is very largely neutralised by a decrease in the size of the received signals. While, therefore, we are not very sanguine as to any great improvement in this direction, we are pleased to be re-assured, and trust that the great expectations of others may be realised.

An American Opinion of the Gas Engine.

Our New York namesake believes in the gas engine, but draws attention to its weak point as a motive power for electrical tramway and railway work. For lighting when loads do not exceed a maximum that can be foretold, as, for example, in the case of private house or theatre installations, the gas engine can show for itself a very good record. But a gas engine cannot deal with an overload. The maximum power of a gas engine is measured by the fullest possible explosion occurring every cycle with no misses. But every one of these working strokes is an expansive stroke. There is no such thing as carrying initial pressure for half, two-thirds, or even three-quarters stroke as is possible with the steam engine. The steam engine will go on working, with less economy, it is true, up to the maximum possible admission. The gas engine goes on working and becomes more economical as the load is increased up to the maximum. It refuses then to proceed further: it will not work on uneconomical rates of overload, but will work as wastefully as possible at light loads. The steam engine will work either under or overloaded, and in both cases it would be wasteful. Our contemporary hopes someone will some day find the plan for enabling a gas engine to work at overloads. By the use of very large engines, of course, the difficulty could be overcome, but this would imply a reserve of explosion strokes so large as to make the engine most wasteful at ordinary powers. Overloads are the normal condition of traction plant for so many periods during the day that the gas engine is placed quite outside the list of suitable prime movers, and the only visible solution of the difficulty lies in the direction of accumulators. With a suitable accumulator worked in parallel with the dynamo so as to absorb and give out the difference of energy as it was manufactured or called for, the objection to gas engines for traction work would cease. Without the accumulator the necessary extension of pressure for nearly the whole of the stroke is not an easy thing to produce; that some device may be forthcoming as desired by our contemporary may be so, but the problem is difficult of solution with economy. Indeed, without economy there will be no easily invented system for securing the desired ends. We also believe in the gas engine, but perforce must recognise its limitations.

ELECTRIC POWER TRANSMISSION IN FACTORIES.

[COMMUNICATED.]

THERE are many cases where it would be a waste of money to apply electricity—such as, for instance, the grouping of a number of small machines driving by a well-arranged system of shafting, where the friction losses would not be much greater than the electrical losses; at any rate, not sufficient to warrant the outlay, which is always bound to be high if the work be done in a thoroughly efficient manner. Not long ago a paper was read before the Manchester Association, advocating the application of electric power in cotton mills, but of all fields open to electric purposes, a cotton mill offers the least scope, for in this branch of industry greater attention has been given to economical transmission by mechanical means than in any other, and the grouping of machines as required in cotton mills makes a line shaft necessary, so that the most one could do would be to apply a motor direct on to each line of shafting; but seeing one is able to drive by rope direct from engine pulley on to each range of shafting, we get very trifling losses compared to what we should get electrically. A cotton mill offers no field whatever for electric power to be commercially practicable.

On the other hand, there are other industries that offer ample scope for electric power, and in which very large economies may be effected. The conditions required to make this possible are where the power is transmitted through a large quantity of badly arranged shafting where the friction losses are very heavy, or where the power is derived from a number of small engines, or where the engines are situated at some distance from the boilers, and there are a great number of such cases especially in the dyeing, bleaching, and finishing trades.

In Lancashire there are many instances where there are over 50 small engines in one works. The losses going on every year in such cases are enormous, and is a point that has been lost sight of by the manufacturers. The chief reason why small engines are applied is because in such works the machines are necessarily scattered, and as the machines require to be easily controlled as to stopping, starting, and varying speed, so the manufacturer has applied the power that was to hand, not considering the wasteful method employed; but latterly manufacturers have wakened up to the fact, and at the present time there are a number of electrical plants at work in and around the Manchester district driving the various machines used in calico and finishing trades, and the Clayton Foundry Company, who may be considered among the pioneers in advocating the application of electric power in this particular trade, have had motors running for nearly three years to the entire satisfaction of the users, and latterly they have just completed a plant that may be considered the most complete, as far as power transmission, at the works of James Chadwick, Limited, Rochdale, where calico printing, dyeing, raising and finishing work is carried on.

Some 12 months ago Messrs. Chadwick, Limited, contemplated removing their works from Littleborough, and consulted the Clayton Foundry Company, Limited, as to power transmission, and ultimately placed themselves in their hands to carry out for them the best system of power application possible, either mechanical or electrical. So, after very careful consideration, works were planned to suit the requirements of the business. In the first place a departure was made from the usual practice, in this class of works, by putting down a first-class modern engine of low coal consumption. This engine is a compound tandem Corliss, with Nuttall's trip motion, working with an initial pressure of 120 lbs. and a speed of 86 revolutions per minute, constructed by the Clayton Foundry Company.

One feature about the engine is the large diameter and extra weight of the fly-rope pulley, which is provided to obtain steady voltage when load was suddenly thrown on to engine. Ropes were decided upon for the mechanical method of driving, and geared wheels are not used in any instance. From the fly-wheel the drive is forwarded on to main line shaft, which in turn drives three lines of shafting in the raising department. These machines being constant in speed and load, is one of the cases in which nothing was to be gained by adopting electricity. Several other machines, under practically the same conditions, were also so driven; for the rest of the power electricity was decided upon, and a 100-H.P. dynamo, of the multipolar type, and built by the Clayton Foundry Company, was put down in the engine house, and one portion of the ropes from the fly-wheel lead direct on to dynamo pulley. No slide rails or setting-up screws are used, and the oiling is all under pressure. In the engine house a large main switchboard is fixed, and contains four main current switches and 15 lighting current switches. A travelling crane is fixed in engine house.

The making-up room being some distance away from any shafting, a 10-H.P. Clayton type motor was put down, driving a line of shafting to run a number of small machines used in making up.

The dye jigs being somewhat similarly positioned, a 10 H.P. motor was fixed direct on to shaft by spur wheel and pinion. The motor runs at 950 revolutions and shaft at 120 revolutions; in this case a small brass pinion is used, and found to answer very well.

The bleach croft being adjacent to raising room, rope driving was resorted to throughout for this department.

In the drying and stentering room a 10-horse motor was used for driving a large mangle; a mortice wheel was keyed direct on to top bowl, and a pinion geared into same from motor spindle. This method of gearing is very good indeed for the heavier machines; the machine running at constant speed, a liquid switch was used for stopping and starting. The power absorbed by machine was, when fully running, 65 amperes, and at starting 110 amperes at 120 volts.

Drying Machine.—For a 21-cylinder drying machine, 9 feet wide, a 3½ H.P. Manchester type motor was used, running at 1,300 revolutions, the speed reduction was obtained by worm gear direct on to the machine, the worm box being fitted with special thrust bearings; the power absorbed by this machine was very small indeed, being about 1½ H.P. This machine being required to run at various speeds, a metallic rheostat is used which gives a range in speed of 40 per cent.

Back Filling Mangle.—This being a machine similar in size to the two-bowl mangle, and the pressure on the bowls being about equal, but running at a rather lower speed and owing to construction of machine it did not lend itself so well to spur gear as the other, a 10-H.P. worm geared motor was fixed direct on to top driving bowl, and the power absorbed when at full work is 50 amperes and in starting up 85 amperes, and although the efficiency tests for worm gear have not yet been taken it is clearly proved in this instance that worm gear if properly designed is not a wasteful gear as so often asserted, while in connection with motor work it is, as was always asserted to be the case by the late Mr. Anthony Reckenzaun, an ideal gear, being noiseless and giving quick reduction. This machine is also operated with liquid switch.

Stentering Machine.—This machine is an ordinary pin stentering machine and about 72 feet long, in front of which is placed a set of drying cylinders, a 10-H.P. Clayton type motor driving the combined machines by belt direct on to stentering machine. This machine having to run at various speeds a metallic rheostat is used.

Fan.—In connection with stentering machine a 36 inch fan for forcing air through steam heater is used; a 5-H.P. motor is coupled direct on to fan spindle and makes 1,200 revolutions.

Printing Machines.—In this department there are at present working two four-colour printing machines. Motors of 10-H.P. are used for each machine, the motors being worm geared on to shaft driving direct on to crown wheels. To bring the motor under very easy control a special metallic switch was designed by which a variation in speed of 50 per cent. is allowed, and on no machine does electricity lend itself better than to printing machines. The power absorbed when all four nips are in use is 35 amperes when running at full speed and 75 amperes in starting up.

Open Soaper.—On this machine it was decided to drive direct on to shaft using Hans Reynolds's improved chain and cut wheels; a 10-H.P. motor is used, and is controlled with liquid switch.

Aniline Ager.—A 3½ worm-geared motor is used, and is driven from worm-wheel by chain on to draw rollers; a metallic switch is used to vary the speed.

Colour Shop.—A 2 H.P. motor is used direct to drive colour pan, and is controlled by liquid switch.

D

It should have been mentioned that from main switchboard, cable was run in underground pipes to two distributing boards placed in convenient positions. On each distributing board a switch fuse and ammeter were fixed for each motor, so that the power absorbed by each machine could be seen at a glance. In addition to the power from the same generator, all the lights for the works, some 8 arc and 85 incandescent lights, are supplied, there being no other means of lighting employed.

Later it is intended to take full tests which, when complete, will be furnished. The engine is guaranteed not to take more than 2 lbs. of coal per H.P. hour, and it is in this that the economies of electric application are to be formed, inasmuch as it enables one to use an engine with a low coal consumption as against the very wasteful small engines, wasteful in every sense both in engine friction, exhausting into the atmosphere, and, being a considerable distance from the boiler, by condensation.

In these works in ordinary practice, there would have been fixed about 14 small engines of a total of about 150 H.P., and from tests made at other works we may assume that not less than 12 lbs. of coal per H.P. hour would be used. Now, the electrical losses are less than the friction and condensation losses in the small engines, still allowing the losses to be equal and taking the horse-power as the same, viz., 150, and the engine giving this power taking only 2 lbs. of coal per H.P. hour, we have a saving of 10 lbs. of coal per H.P. hour, or a total of 1,500 lbs. of coal per hour, giving a total saving for six days, at 10 hours per day, of 40 tons, a saving quite warranting the outlay.

This estimate is based upon a trial made at a dye works in Yorkshire, where 38 small engines and two high pressure condensing engines were in use. Some time ago a motor was put to work on a heavy friction Calender at another works, which before the alteration was driven by a pair of 8 × 12 diagonal engines, and carefully indicated by an insurance company to be developing 14 I.H.P., and being some distance from the boilers a considerable amount of condensation was taking place. This machine has now been working for two years, taking 11 electrical H.P. and working quite satisfactorily, although driving one of the most difficult machines in the finishing trade; subsequently two other similar machines were electrically driven with equally good results.

It may be mentioned that all the machinery at the Rochdale works, steam engine, electrical machinery and switchboards, as well as printing, ageing, drying machines, mangles, &c.; in fact, every machine except raising machines have been made throughout by the Clayton Foundry Company, thus giving them opportunities to suit the various machines to electrical driving.

At other works in the neighbourhood this company is running other classes of machinery, such as beetles, mangles, washing machines, &c., and in each case obtaining satisfactory results.

There is nothing of an experimental nature in electric power transmission; it is a cheap, clean and economical method of conveying the power of the engine direct on to the machine if applied in a proper manner. Unfortunately, a practice has sprung up with electrical engineers, brought about by keen competition in electric light work, to state the greatest possible output of electric machines, leaving little or no margin for sudden overload in place of making considerable provision for such, and machines have been put to work and called to be, say, capable of doing 10 H.P., but as stated in the case of the mangle motor, it may be taking only 10 H.P. when fully working, but at the moment of starting 18 to 20 H.P. is required. As a consequence, the machine not being designed for such overload, the fuse or coil burns out, and the machine being broken down, causes trouble and annoyance to the users bringing electric work into disrepute most undeservedly.

Practically, the only trouble arising in electric work is the machines being under their work; if large enough, breakdowns would be very rare indeed. The only drawback in the larger machines is the slightly increased initial outlay, and switches also give some trouble if not properly designed for the work and current to be used.

The essential features necessary to the success of electric power is, first and foremost, a first-class economical engine. The next is to have the machine large enough for its work, and carefully geared to the machine to be driven, dispensing with as much gear as possible by direct application. When this is done, electric transmission will prove a source of satisfaction and a profitable investment to the user.

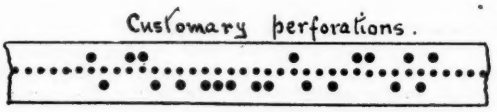
It has been said that it would be folly to take out and discard existing plants. This is a mistake, for it is in these old plants that the greatest waste is taking place. We cannot think that the manufacturers in this country are less enterprising than the manufacturers on the Continent, where electricity is making such rapid strides. In one case an old concern took out all their old engines, substituting electricity at an outlay of £14,000, which sum they expect to have returned in four years.

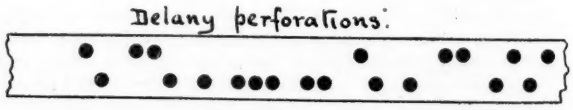
THE FUNCTION OF THE ELEMENT IN CABLE SPEEDS.

By E. RAYMOND-BARKER.

The theoretical speed of electrical transmission on any submarine telegraph cable is easily arrived at on the basis of Lord Kelvin's famous investigations, and by a simple calculation, the value a for any core, past, present, or future, of given dimensions, material and length, may straightway be obtained.

No definite standard, however, in terms of which the commercial carrying-capacity of a cable can be satisfactorily expressed, has, as yet, met with universal adoption, and in this connection the writer trusts that the following investigation will be found to have thrown some little light on this not unimportant subject.





Some authorities have expressed rates of speed in terms of (*a*) *signals* per minute, whilst others have taken (*b*) *letters*, and others (*c*) *words* as units of carrying capacity per minute.

Neither (*a*), nor (*b*), nor (*c*), affords a final or ultimate unit, not even the first-mentioned, failing, as it does, to duly recognise the status of the *space* as a factor in efficient signalling, equal in importance to the *signal* itself.

The objection may be raised that mention of signals per minute takes for granted existence of intervening spaces. Space value, however, in practical signalling varies with circumstances, and considered severally as intervening between (1) parts of letters; (2) between letters; (3) between words, varies as 1 : 3 : 7. It is therefore evident that the ultimate unit upon which all practical standards must be based, will be one in terms of which the comparative time-value of spaces just as much as of signals, may be correctly expressed.

When (*a*) is inaccurate, it is not to be expected that (*b*) or (*c*) can be taken as satisfactory bases, and this, for many reasons, the most obvious one being that they do not allow for varying space values.

The man commercially connected with submarine cable projects is interested in knowing the carrying capacity of cables, and he likes to have this value stated in terms, the meaning of which he can at once grasp. He knows nothing about *signals*. The speed-rate stated to him in *letters per minute* at once makes him cogitate as to what that may mean in *words*. Words, and words only, satisfy him—5-letter, 7-letter, or 10-letter words, as best may suit his purpose.

So the telegraph engineer states his calculated speed-rates in terms of *words per minute*, but he must have a care that these words be based upon an accurate and ultimate unit in terms of which the comparative time-values, whether of signals or of spaces, may alike be correctly expressed.

The element is proposed by the writer as this ultimate unit.

The meaning of the term "*element*" is graphically illustrated by the accompanying drawing of corresponding instrument-tapes which show, *inter alia*, how any form of telegraphic code, whether siphon-recorder, or Morse, may be resolved into values in terms of one ultimate value, the *element*.

The words "set it up" are chosen for brevity, and as affording compact illustration of spaces between words.

The building up of an accurate *word* standard based on the *element* will be here described. Salient points may be summarised as follows :—

1. Adoption of the *element* as basis of comparative time value—as, in fact, *traffic unit*.

2. Determination of comparative time-value (v) of the average telegraphic code *letter* in terms of the *element*, taking into account spaces between signal s, *i.e.*, parts of letters (1°) v for siphon recorder (2°) v for Morse.

3. Formula for reducing any general statement as to cable traffic to *words per minute* of any convenient number (N) of letters per word, with due regard to all spaces.

4. Tabulation of *constants* C_n which, when divided into *elements per minute*, give speed-rate in N-letter words per minute, taking exact account of all spaces. (1°) C_n for siphon recorder (2°) C_n for Morse.

5. Calibration of perforated tape lengths in terms of elements.

6. Practical examples illustrating various cases.

Referring to former diagram :—

Let the fundamental *element*, whether contact or space	...	...	$= e$
Each contact or signal	...	...	$= 1e$
Each space between contacts	...	...	$= 1e$
Each space between letters	...	...	$= 3e$

viz., $2e$ in excess of space between contacts.

Let v represent number of elements per letter of the siphon-recorder code, including extra spaces between letters, as averaged from the letters composing 1,000 words of ordinary journalistic language, and thus ascertained to be

$$v = 7{\cdot}157\ e.$$

For if E_1 = Number of contact *elements* contained in 1,000 words of ordinary language, (in present instance) ... = 12,493.

E_2 = Number of space elements intervening between contact elements . = 12,492.

E_3 = Number of *extra* space elements following after letters ... ... = 9,686.

l = Total number of *letters* included in the above-mentioned 1,000 words . = 4,844.

Then
$$\frac{E_1 + E_2 + E_3}{l} = v \qquad (1)$$

or

$$v = \frac{12{,}493 + 12{,}492 + 9{,}686}{4{,}844} = 7{\cdot}157 \text{ elements per letter.} \qquad (2)$$

Each word is followed by a space interval equivalent to $7\ e$, viz., $7 - 3 = 4\ e$ in excess of space between letters.

Let W words with a total of L letters be signalled in T minutes, the intervening spaces between words thus numbering $W - 1$.

It is pre-supposed that in the case in point, there have been no pauses in the signalling to cause gaps in the series of recorded signals on the paper tape.

Let X = required number of N letter words signalled per minute, taking into account all spaces.

Then
$$x = \frac{\{[L\,v] + [4(W-1)]\}\ \frac{1}{T}}{v\left[N + \left(4\,\frac{v}{N}\right)\right]} \qquad (3)$$

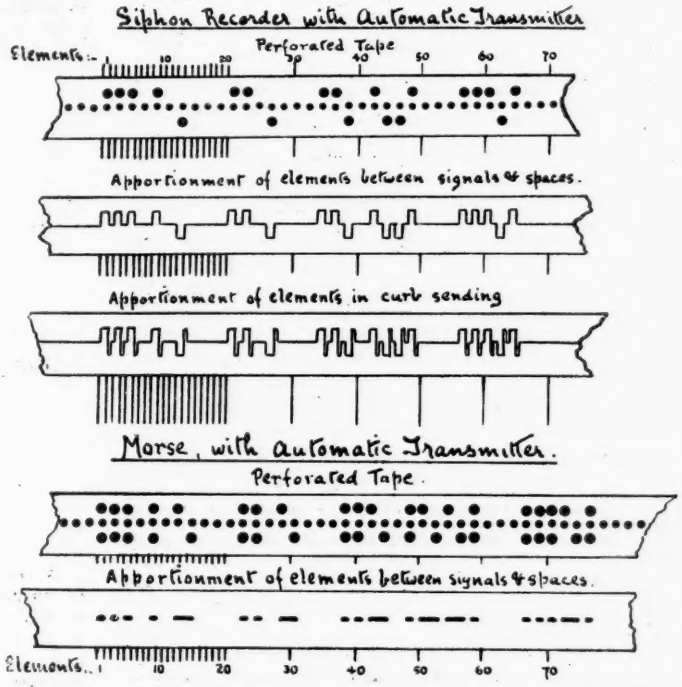
The denominator of this expression is a *constant* (C_n) for words of N letters.

That is

$$x = \frac{\{[L\,v] + [4\,(W-1)]\}\ \frac{1}{T}}{C_n} = \frac{\text{Elements per min.}}{C_n} \qquad (4)$$

Constant C_n if required to express speed-rate of working in 3-letter, 5-letter, 7-letter, or 10-letter words severally becomes—

$$\text{Constant } C_3 = v\left[3 + \left(4\,\frac{\frac{1}{v}}{3}\right)\right] = 22{\cdot}807 \qquad (5)$$



Graphic Analysis of Comparative Values of Telegraph Signals in Terms of a True Primary Unit, viz., the Element.

$$\text{Constant } C_5 = v\left[5 + \left(4\,\frac{\frac{1}{v}}{5}\right)\right] = 36{\cdot}588 \qquad (6)$$

$$\text{,, } C_7 = v\left[7 + \left(4\,\frac{\frac{1}{v}}{7}\right)\right] = 50{\cdot}675 \qquad (7)$$

$$\text{,, } C_{10} = v\left[10 + \left(4\,\frac{\frac{1}{v}}{10}\right)\right] = 71{\cdot}979 \qquad (8)$$

Ex. :—Actual words numbering 2,000 (W) including preambles, repetitions, collations, &c., and comprising 8,600 letters (L) were signalled in 105 minutes (T) through a certain cable.

The mean rate of speed in terms of *5-letter words*

$$= \frac{\{[8{,}600 \times 7{\cdot}157] + [4\,(2{,}000 - 1)]\}\ \frac{1}{105}}{C_5}$$

$$= 18{\cdot}1 \text{ words per min.}$$

whilst in terms of *7-letter words*, speed-rate would be

$$= \frac{\{[8{,}600 \times 7{\cdot}157] + [4\,(2{,}000 - 1)]\}\ \frac{1}{105}}{C_7}$$

$$= 18{\cdot}1 \text{ words per min.}$$

Sufficient evidence of the necessity of some formula in which speed-rate of cable transmission may be accurately stated is afforded by an example here quoted, and given in various editions of a well-known and valuable electrical pocket-book:—

"... A thousand code words were sent .... in 81 minutes, including all repetitions and collations. They contained 7,288 letters, equivalent to 1,458 words of five letters each. The rate of transmission is therefore 18 words of five letters per minute...."

Now this expression $\left(\frac{\frac{7,288}{5}}{81} = 18\right)$ does not accurately state the case. The correct formula is

$$= \frac{\{[7,288 \times 7{\cdot}157] + [4\,(1,000 - 1)]\}\,\frac{1}{81}}{C_5} = 18{\cdot}95$$

say, 19 5-letter words per minute. This improvement of 5 per cent. on the former figure is solely due to allowance having been made for all extra time-value involved by efficient spacing between words.

If, in the preceding example, one suppose that the 7,288 letters be contained in 1,822 four-letter words, the mean speed of signalling by the writer's formula becomes 20 5-letter words per minute. If, on the other hand, the 7,288 letters be taken as comprising 911 words of eight letters each, the calculated speed falls to 18·8 5-letter words per minute.

Thus the same number of letters transmitted in a given time evidences a higher, or a lower speed, according to the number of actual words which the said letters compose. The more words there are in a given number of letters, the greater becomes the space value to be taken into account.

These obvious facts are here alluded to only to emphasise the necessity of basing all speed calculation on the *element*, the fundamental unit, alike of space, and of signal. The formula proposed by the writer has the *element* for its basis, and is correct, once it is granted that 7·16 (v) is the true average number of elements per letter as used in ordinary language.

The foregoing investigation has dealt with the calculation of the mean rate of speed actually obtained in practice on a submarine telegraph cable. A test of this nature is best taken when traffic on the cable is at its highest pressure, and when an uninterrupted series of messages transmitted at a maximum safe rate of speed, may be relied upon for an extended period of time, say, for two or three hours.

Frequently, however, it is a question of ascertaining merely the speed-rate, in terms of N-letter words per minute, at which the perforated strip is passing through an automatic transmitter. This is simply a matter of dividing the total number of elements passing through the transmitter in one minute by *constant* C_n, the quotient giving the rate of speed in N-letter words per minute.

Ex.:—A paper band with perforated signals equivalent to [585 contact + 584 space elements =] 1,169 elements was run through an automatic transmitter in 54″, which is at the rate of 1,299 elements per minute.

Speed of transmission in 5-letter words was therefore $\frac{1,299}{C_5} = \frac{1,299}{36{\cdot}588} = 35{\cdot}5$ words per minute.

If required in terms of 7-letter words, it would be $\frac{1,299}{C_7} = \frac{1,299}{50{\cdot}675} = 25{\cdot}6$ words per minute.

Obviously, in reckoning the rate of speed at which signals are transmitted, all that is necessary is to count the centre row of holes which enable the star-wheel of the automatic transmitter to carry forward the perforated band. The sum of the centre holes, *plus* the intervening spaces, passing per minute, give the value to be divided by *constant* C_n.

The fact that, on the perforated band, the number of elements per unit of length remains a constant quantity, renders the counting of elements an expeditious operation, as may be seen from Table A.

This is adaptable to all long-cable automatic transmitters excepting Delany's, the perforated band of which differs in certain respects from that used with other apparatus.

In the Delany system of automatic transmission on long submarine cables, an electro-magnetic puncher feeds the transmitter with tape perforated with two rows of comparatively large holes. There is no centre row of holes as is usual in other automatic systems. The two rows of perforations corresponding to *positive*, and *negative* signals, pass between two pairs of copper wire brushes which effect contact only when enabled to do so by the passing of a hole in the perforated band. The brush contacts have no direct relation with the cable circuit, as they merely work a pair of sounder repeaters which constitute the actual cable transmitter.

TABLE A.

Length of perforated paper tape.

Yards.	Feet.	Inches.	Mètres.	Dm.	Cm.
723	241	20	787	79	8

Total number of elements.

On the Delany perforated band a continuous series of perforations in either of the two lines numbers 267 per yard, which is equivalent to [267 contact + 266 space =] 533 total elements per yard, as given in Table B.

TABLE B.

Length of Delany perforated tape.

Yards.	Feet.	Inches.	Mètres.	Dm.	Cm.
533	180	15	581	58	6

Total number of elements.

Ex.:—Perforated tape 5 yards 1 foot 1 inch passed through a Delany transmitter in 3 minutes.

$$[5 \times 533 =]\ 2,665 + 180 + 15$$
$$= 2,860 \text{ elements in 3 minutes, viz.:}$$
$$\frac{2,860}{3} = 953 \text{ elements per minute.}$$
$$\frac{953}{C_5} = 26 \text{ 5-letter words per minute.}$$

A simple approximate method for noting the speed-rate of automatic signalling is to observe the revolutions per minute of the friction roller which works in with the star-wheel, and which is known to carry through, say, 40 total elements on the perforated tape per revolution. In one of the previous examples, the friction-roller was observed to make 32·5 (approx.) revolutions in one minute.

Then $\frac{32{\cdot}5 \times 40}{C_5} = 35{\cdot}5$ 5-letter words per minute.

A drawing is given which shows paper tapes punched with (1) ordinary, and (2) with Delany perforations.

To apply equation (3) to Morse signalling, in which the "*dash*" has three times the time-value of the "*dot*," instead of being equal, as in the siphon recorder code, it is necessary to modify the numerical value of v.

Let each recorded *dot* = 1 e. (See former diagram.)
" " " *dash* = 3 e.
" " space between contacts = 1 e.
" " space between letters = 3 e, viz., 2 e in excess of space between contacts.

The same 1,000 words of ordinary journalistic language alluded to in the former examples are again taken as basis for calculating v for Morse work.

Total number of contact elements = 22,013 = E_1.
Space elements between contacts ... = 12,492 = E_2.
Extra space elements between letters = 9,686 = E_3.
Total number of actual letters included in the said 1,000 words ... ... = 4,844 = l.

Then $v = \frac{E_1 + E_2 + E_3}{l} = 9{\cdot}123$ elements, being average number of elements per Morse code letter in 1,000 actual words.

Therefore, formula $C_n = v\left[N + \left(4\frac{\frac{1}{v}}{N}\right)\right]$ applied as in

expressions (5) (6) (7) (8), with $v = 9{\cdot}123$, gives

$$\left.\begin{aligned} c_3 &= 28{\cdot}703 \\ c_5 &= 46{\cdot}416 \\ c_7 &= 64{\cdot}432 \\ c_{10} &= 91{\cdot}633 \end{aligned}\right\} \text{Constants } c_n \text{ for Morse.}$$

These *constants*, c_n, are values which, when divided into the total number of elements signalled per minute, give rate of working-speed in terms, severally, of 3, 5, 7, or 10-letter words as required.

Ex. (1):—On a Wheatstone automatic circuit 2,000 words (W), comprising 8,600 letters (L), were signalled in 15 minutes (T).

By equation (4), required speed-rate in, say, 5-letter words per minute

$$= \frac{\{[8{,}600 \times 9{\cdot}123] + [4\,(2{,}000 - 1)]\}\ \frac{1}{15}}{c_n \text{ (for Morse)}}$$

$$= \frac{5{,}764 \text{ elements per minute}}{46{\cdot}416} = 124 \text{ 5-letter words per minute.}$$

Ex. (2):—On a Wheatstone automatic circuit, perforated tape passed through the transmitter at the rate of 9 yards, 1 foot per minute

From Table A this is found to be at the rate of 4,977 elements per minute, which is $\frac{4{,}977}{46{\cdot}416} = 107$ 5-letter words per minute.

When one deals with speed-rate of secret cipher traffic made up of letters grouped indiscriminately, it is best to take for v the average number of elements per letter in the international code alphabet.

On this alphabetical basis $v = 8{\cdot}19$ for siphon-recorder, and $11{\cdot}12$ for Morse.

These last-mentioned values for v are not, however, applicable to the foregoing examples, owing to the letters in most frequent use being the shorter ones in the telegraphic code, and it is for this reason that v for general purposes has been calculated on a more practical basis.

Special values for v may also be arrived at, applicable to groups, or to any series of figures, whether signalled in full, or abbreviated.

It may be urged that the writer has unduly elaborated a very simple matter. His object, however, has been not so much to deal with mere circuit speed rates, as to suggest a *standard* method for conducting really satisfactory trials of speed on laid cables, with a view to the resultant data being adopted as basis for future calculations in the design of cable cores.

ACCUMULATORS FOR RAPID CHARGING.

By L. EPSTEIN, M.I.E.E.

In the paper recently read by M. Blanchon before the Société Internationale des Electriciens, the author anticipates that his company (the Tudor Company), evading the mistakes made before, and endowed with wisdom (sagesse) denied to their predecessors, are destined to efface the disfavour in which traction by means of accumulators is still held, even by many electricians.

After describing the present Tudor accumulators for traction, the plates of which develop up to 10 times the surface of a plain plate of the same outside dimensions, the author says that the capacities range from 6 to 8 ampere-hours to 3½ to 4 ampere-hours per kilo positive and negative electrodes combined, at discharge rates from 1 ampere to 6 amperes per kilo. of electrodes. These capacities are moderate, being surpassed by other accumulators of the Planté type; but evidently the makers find it advisable to sacrifice lightness to durability.

The capacities at different discharge rates are given, the discharge in six hours being taken as a basis, as 65 per cent. at a two hours' discharge, 45 per cent. at one hour's discharge, and 30 per cent. at a half hour's discharge.

The desiderata of batteries for traction purposes being lightness, large capacity and heavy discharge rates, M. Blanchon adds that the fulfilment of all these conditions is incompatible at present, and that the Tudor Company elect to sacrifice part of the first two advantages, viz., lightness and large capacity, and prefer to instal batteries once for all in the cars of sufficient capacity for the day's total run, without, as a rule, drawing out more than two-thirds of the total capacity, the charging being done at the terminus during the shortest possible time, never exceeding 20 minutes, and often not occupying more than 15 or even 12 minutes.

The author cites from papers read as far back as 1891, and from an article by M. Hospitalier and M. Picou in *L'Electricien* of August 1st, 1891, dealing with the method of charging not at a constant current but at a constant voltage which enables a much more rapid charge at the initial stage, a very heavy current passing at the beginning and gradually decreasing as the counter E.M.F. of the cells rises, until a point is reached when the current practically drops to zero.

The advantages claimed for this method are—

1. Less wear and tear of batteries.
2. More rapid charge in the initial stage.
3. Suppression of vigorous gassing and consequently better conservation of the electrodes, prevention of overcharge and subsequent useless work.
4. Reduced voltage of dynamo.
5. Less supervision required.

When charging at 2·3 volts per cell it has been found that it was possible to store within the first hour 50 per cent. of the total charge, at the end of the second hour 75 per cent., and at the end of the third hour 83 per cent.

Of course it will be understood that the time required for a full charge is not reduced, as the rapid charge at the beginning is counterbalanced by the gradually diminishing current as the charging proceeds, and more especially towards the end of the charge.

The methods of using accumulators for traction purposes are enumerated by the author as follows:—

1. Direct accumulator traction.
2. Mixed system of accumulators in car and trolley or conduit.
3. Accumulators in fixed stations working in parallel with dynamo.

With the last-named system it has been found that the variations in the voltage, which were formerly abnormal, were reduced to about 8 per cent., the heavy demand for current being almost exclusively furnished by the battery.

Referring to the Puteaux line, where self contained cars are run, the weight of the accumulator battery, which consists of 200 cells, is given at 3,620 kilos. These cells are always charged and discharged in series, the car carrying two motors.

No reason is given why the well-known arrangement of dividing the batteries into a number of groups, to work either in parallel or series has not been adopted, nor is any information forthcoming with regard to the resistances in circuit and the loss entailed thereby.

The discussion which followed was of rather a meagre character, and failed to supplement the want of precise information and figures in the paper, an omission rather adversely commented upon by the President.

The question of traction by means of self-contained cars is of such paramount importance, that anything tending to elucidate facts, or even only indicate methods that promise well, should be welcome. In the interests of final success, it is desirable that no statement should be allowed to pass unchallenged, unless it is supported by reliable figures and data.

Now, without wishing to detract from the merits of the system advocated by M. Blanchon, the fact must not be lost sight of that the paper only shows one side of the medal—the most favourable one, the obverse—and it behoves us to look at the other side, the reverse.

A more careful examination of the advantages claimed for the system under review leads us to the following considerations:—

1. Less wear and tear of a large battery installed in the car as compared with smaller batteries that have to be exchanged.

It being a fact that both the mechanical conditions (jolting and jarring), and the electrical treatment (heavy discharges) are necessarily severe, it seems to me that with proper appliances the exchanging of the batteries could be effected with a minimum of detriment to the plates.

2. A more rapid charge at the initial stage.

This is undoubtedly an advantage, enabling the batteries to recoup themselves very quickly and thus to do a larger car mileage.

On the other hand, this rapid charging necessitates a much larger generating plant, making the first outlay much heavier, and also entailing a larger sum being set aside for interest, repairs, and depreciation of plant. To put it tersely, while when charging at continuous current the generating plant can be used during a maximum of time at a uniform rate, charging at constant voltage will utilise the maximum output only during a fraction of the above time, the rates will vary within wide limits.

3. Suppression of vigorous gassing and prevention of useless work.

This object can also be attained when the differences between maximum and minimum of charging current are less exorbitant, that is to say starting with a certain current (far below that used in the charges of 20 or less minutes' duration) and reducing the rate towards the end of the charge.

4. The alleged advantage of reduced voltage of the dynamo is more than compensated for by the increased amperage. It is evident that the maximum reduction in voltage is limited to about 90 per cent., say a saving of 10 per cent., while the increased capacity for current will necessarily require plant of twice or three times the capacity as compared with a constant current output.

But there are other important considerations which are ignored in the paper.

Basing our calculation on the Tudor cell type 2,002, weighing complete 18·1 kilos, its capacity is given as 60 ampere-hours when discharged in one hour, which corresponds with about 130 ampere-hours at a six hours' discharge. The battery for a car on the Puteaux line for 56 passengers consists of 200 cells, weighing 3½ tons, or in other words, probably quite one-third of the total weight of car with full complement of passengers, and a higher percentage when the car is empty or only partly filled.

It is well known that certain items of expenditure bear a direct ratio to the weight to be propelled, such as fuel, oil and waste, repairs and renewals of cars, and most important of all, maintenance of permanent way. Besides, the heavier battery requires a heavier car and more powerful motors than would be the case with a lighter battery, thus increasing the weight all round.

Experience alone will show whether rapid charges and heavy batteries fixed permanently in the car, or moderate charges and lighter batteries which are exchangeable, give the best commercial results; probably the most satisfactory solution will be found in a compromise between one and the other.

ELECTRIC TRAMWAYS AND LOCAL AUTHORITIES.

The respective positions of tramway company and local authority is of growing importance now that electric traction has come to the front; and some few notes bearing upon the subject may therefore be of value. The following paragraphs are compiled by a practical man of experience in this direction; they contain some useful suggestions, and a good deal of controversial matter. These columns are open to the ventilation of opinions thereon; and some of our readers will perhaps take the hint, so far as to refute or confirm what is said:—

1. *Permanent Way.*—Although many (perhaps most) existing tramway companies both own and look after the permanent way of their lines, there are greater advantages in this section being entirely in the hands of the local authority. The constant tendency is to-day in this direction. The local authority has always a road staff of some kind, and this could be advantageously used for the tramway work also—avoiding extra supervision and clerical work. In such cases a fixed rental is, of course, paid by the tram company: probably a small minimum is agreed upon, plus a further amount proportional to the car mileage and consequent wear and tear. One difficulty (from the company's standpoint) is to ensure that the Corporation shall not stint the repairs, &c.; otherwise the company might possibly suffer not only from increased working cost, but actual loss from stoppage of traffic.

2. *Overhead Equipment, &c.*—There does not seem any actual necessity for the Corporation to own this part of a tramway system, nor is it, perhaps, so advisable as with the track. Local authorities have, of course, a right of deciding upon the particular type and mode of equipment to be employed, since they are the guardians of the public streets, and hence responsible for *permanent structures*; but beyond this there is no actual need or advisability for them to own and look after the overhead work. It would probably lead to disputes if they did, as the risk of damage is much greater with overhead work than with the track; and the question of how much the company should pay for maintenance if the Corporation owned and repaired the overhead work, is not an easy one to settle; no general rule could be given, as local conditions would cause great difference in the ruling circumstances. In any case the repairs to overhead construction are best done by the tramway company and not by the Corporation.

3. *Generating Station.*—Seeing that most corporations are either proposing to instal, or have already installed, a public supply of electricity for lighting from a municipal station, it seems strongly advisable to employ the same plant, at least partly, for the supply of energy for tramway purposes also. Tramways runs essentially through busy districts that also require light, both privately and along the thoroughfares; hence the two go hand in hand, or should do so. The generating station may therefore be safely left with the local authority, subject to such conditions of supply to a tramway company, that the cost of energy shall not be excessive, and that the supply shall be continuous and regular, under penalty with failure.

4. Where the corporation thus erects a generating station, primarily for electric traction, the chimney, boilers, condensing plant, &c., should all be designed at the outset of at least double the maximum capacity, if a supply for electric lighting is also contemplated from the same station. There is no great economy or advantage in arranging for the same steam units to be used for both purposes; indeed, this cannot readily be done as the lighting and power loads overlap in the evening. The best plan is to have part of the tramway or power plant so arranged as to feed accumulators for the low tension lighting circuits, and to use high tension lighting machines made capable of working the power circuits by means of alternating motor generators in sub-stations.

5. If a tramway company has installed, or should instal, a generating station for electric traction, the possibility of its being taken over by the local authority would be provided for and governed by the terms of lease under which the company operates its lines, or the general conditions of the Tramways Act. Buildings and plant would be taken over at their "then value;" but obviously better terms than this would be desired by the company, and would be secured by them if possible.

6. When the entire plant, track, overhead structure, power house, &c., save and except the motor cars, is provided by the local authority, the company has practically then to pay for:—

1. Motive power.
2. Repairs to fixed plant.
3. Depreciation on same.
4. Sinking fund.

The first is calculated at so much per unit consumed (care being taken to make the waste a minimum) or per car mile, if that can possibly and legally be arranged; repairs can be calculated, as already stated, on a fixed minimum plus an amount proportional to the car mileage, so far as track and overhead structure are concerned; power house repairs should of course be covered by the payment for motive power, also depreciation and sinking fund on same; depreciation on track and overhead structure, &c., is calculated at fixed rates for percentages on the outlay; and similarly, with the sinking fund, dependent, of course, upon the term of loan contracted by the local authority for the outlay required.

7. When the company owns and operates the entire plant and system the local authority is enabled, under the Tramways Act, to take over the lines (and work them also according to a recent decision) at the end of lease, or at each subsequent period of seven years, practically at scrap value.

The local authority is at any rate well protected under this Act, and in the case of tramways built under special Acts, the local authority would of course have a clause inserted to provide for purchase or taking over of the system at any stated period on terms to be arranged.

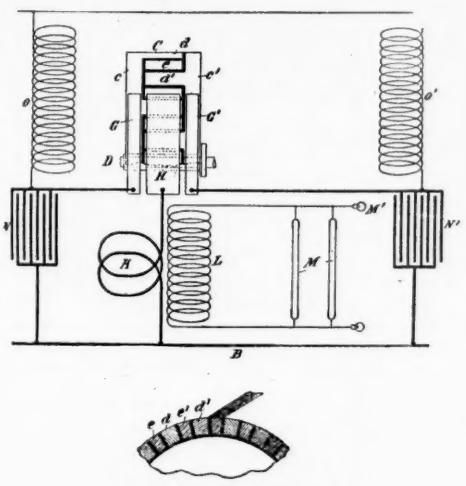
8. Probably the best and most satisfactory arrangement—at any rate in the meantime—is for the local authority to provide electric energy from a municipal station, designed also for electric light and supply; and also to lay down, repair, and maintain the permanent way, including of course the bonds, &c., and the feeders. The tramway company would then on payment of agreed sums or rentals, operate the lines under lease (which should not be less than 21 years, subsequently renewable for periods of seven years if so agreed upon) installing, repairing, and maintaining the overhead structure (subject to the borough engineer's approval) also motor cars and rolling stock generally.

A NEW TESLA CONTINUOUS HIGH FREQUENCY GENERATOR.*

In the forms of high frequency generators heretofore devised by Mr. Tesla, and in high potential generators generally, a cessation of flow has naturally been caused during the interruption of the circuit necessary to obtain the "break." In order to produce a continuous high frequency discharge Mr. Tesla has recently designed the apparatus illustrated diagrammatically in the accompanying engravings.

Briefly stated, the apparatus consists in the combination of two condensers with a circuit controller of such character and so operated by a single motive device as to charge and discharge the condensers alternately, whereby one will be discharging while the other is being charged, and conversely.

The spaces between two adjacent commutator bars, *d d'*, fig. 2, are equal in arc to the width of one of the bars, and are filled in with blocks of metal insulated from the other conducting portions of the device. The two heads, *c c'*, are



Figs. 1 and 2.

insulated from each other. Upon the periphery of this commutator bear three brushes, G G' H, the two former resting upon the continuous metallic portions of the two heads, respectively, the latter being in position to bear upon the projections, *d d'*, and blocks, *e*, alternately.

The brush, H, is connected to the main, B, through a primary coil, K, of low self-induction in inductive relation to a secondary, L, which constitutes the ultimate source of the current of high frequency which the apparatus is designed to develop. The brushes, G G', are connected with the main, B, through condensers, N N', respectively, and to the main, A, through self-induction or choking coils, O O', these latter being used in order that the inductive discharge of the accumulated energy therein may be taken advantage of in charging the condensers.

The operation of the apparatus is as follows:—By the rotation of the commutator, C, the brush, H, is caused to pass over the projections, *d*, closing the circuits through the primary, K, and the two cylinders alternately. These two circuits are so adjusted as to have the same capacity, self-induction, and resistance. When this brush is in electrical connection with any projection, *d'*, from the part, *c'*, the circuit is closed between mains, A and B, through coil O', brush, G', brush, H, and coil, K. Energy is therefore accumulated in the coil, O'. At the same time the condenser, N', is short-circuited through the brush, G', brush, H, and coil, K, and discharges through this circuit the energy stored in it, the discharge being in the form of a series of impulses which induce in the secondary, L, corresponding impulses of high potential. When brush, H, breaks the circuit through coil, O', the high-potential discharge or "kick" from the latter rushes into and recharges the condenser, N', but as soon as the brush, H, has passed over the intervening block, *e*, and reached the next segment, *d*, it closes the circuit through coil, O, and short-circuits the condenser, N, so that high-frequency currents from either one or the other of the two condensers are flowing through the primary, K, practically without interruption. Thus without increasing the size or power of the motive device or complicating in any material degree the commutator, these devices are made to perform double duty and the output of the apparatus as a whole greatly increased.

It is also evident that all phase differences in the charging and discharging of the condensers may in like manner be obtained, and the same motor and circuit-controller might be made to charge more than two condensers in succession and to discharge them in the same order.

* New York *Electrical Engineer*.

RUBBER AND COMPOUND INSULATION.

Many and grave are the complaints made against and objections offered to India-rubber as a cable insulating material by those who have had an unfortunate experience with this material. Apart from electrical considerations the cost of vulcanised rubber of the best quality has deterred many engineers from continuing to purchase cables so insulated, and manufacturers have consequently sought for reliable and suitable substitutes. Impure rubber, or rubber compounds, are meeting with some favour, while jute, paper, and similar substances are being used in large quantities. But it has been found, as might be expected, that in certain cases and for some purposes vulcanised rubber possesses advantages that strongly recommend it, and therefore we find that it still holds its own place and has its supporters, amongst these being numbered many of the most experienced men in the industry who know exactly how to treat rubber cables and keep them up to the work they have to perform.

The demand for compound cables has stimulated firms, who until quite recently confined their attention to rubber, to produce something which could be offered to their clients as an alternative. Consequently, one firm handles rubber, and cotton-covered cables immersed in resin oil; another, rubber and impregnated jute; a third, rubber and an impure or compound rubber; and a fourth has now taken up the manufacture of rubber cables as a relief from the monotony of a compound insulation. Paper, again, is having a good share of the business going, while the older established bitumen maintains the creditable position it gained from six to ten years ago.

Just as opinions differ, so experience does not always tell the same tale, and it may be worth while recounting a little bit of history in connection with the cable system of the West End Street Railway Company, of Boston, U.S.A., partly for the lessons to be learnt, but more for the sake of the knowledge that we are, or seem to be, able to do better in this country with certain classes of insulation than has been the case in the country of their origin.

The West End Street Railway Company had to make some extensions and alterations early in 1895, and in or about March of that year put down some 25 miles of 500,000 circular mil (say 0·4 square inch) conductor paper and fibre insulated cables. By so doing, we believe, they saved about £3,000 as compared with rubber. Unfortunately, 11 faults

appeared in the first year of working. In America the usual practise when a fault appears is to cut the cable which tests badly at the manholes on the conduit line, take the length section by section until the faulty piece is found; this being then withdrawn and replaced by a section which has to be jointed up on the line. The length of each section is about 130 yards, so that from seven to ten cuts have to be made in a mile of cable to trace a fault therein. Eleven faults mean, therefore, over 200 cuts into the cable, and twice that number of seals, as impregnated cables require careful sealing of ends when cut in this way, otherwise moisture is carried back into the cable several feet from the exposed end. Some hundred odd tests of sections had to be made in location, and then the repairs were effected in the usual way, and as indicated above. Between 1,400 and 1,500 yards of cable, or roughly, 3 per cent. of the whole in use, were employed to effect the repairs, and replacements of faulty lengths.

There is so much in the way a cable is first laid and handled, that we are not surprised to learn the incidents briefly detailed above; but one must admit that the West End people were decidedly unlucky, particularly as another electric tramway concern, with over 50 miles of rubber insulated cable down, were not called upon to make any repairs in the first year, not a single fault having made its appearance in the twelvemonth.

Impregnated or absorbent dielectrics have one marked pecularity, which is sometimes an advantage, inasmuch as they give warning of a developing fault, and consequently with an adequate staff repairs can often be carried out before the cable has got so bad that it has to be withdrawn from service. The location of the fault can be found by a similar method in each case and there are now numerous ways of, at least, approximately determining where the trouble lies, making it unnecessary to mutilate a feeder or distributor by hacking it to pieces in short lengths.

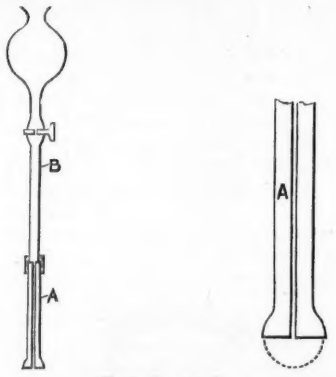
One of the principal advances within the last year or two in the putting down of cable networks underground is the great care taken to afford the cable ample mechanical protection. Whether it be drawn into conduits or laid direct in the ground no fault can now be found with the protection. If the former system be favoured, thick cast-iron, heavy stoneware, or stout bitumen concrete ensures stability, while in armoured cables the armouring is usually thick steel tapes, breaking joint, and held in position by compounded braiding, of which frequently two layers are put on. Particularly where "one cable, one duct" is the rule there is very little to improve upon, and fault-hunting is not an occupation at which the juniors on the staff of a well-managed modern station are likely to become very familiar.

A form of insulation that may be referred to in connection with the above remarks has been introduced in the United States under the name of "Silex." This is a form of pulverised and ground-up rock, and is commonly used as a powder, which may be packed round a bare conductor set in an iron barrel or pipe, so that it forms a separating non-conducting fireproof mass. It is said to have good insulating qualities, to withstand high potentials without breaking down, to be unaffected by heat either electrical or physical, to be non-hygroscopic and unaffected by moisture, non-inflammable, cheap and durable. In fact, it seems to possess all the qualities so much sought after by Mr. Frederic Bathurst, and may be looked upon as carrying his idea of insulated conduits one step further, *i.e.*, one provides the conductor and the conduit, and then fills the conduit with an insulating material that cannot burn, and prevents anything undesirable finding its way into a place where it could create a fault by connecting conduit and conductor together.

Cable breakdowns are not, however, invariably due to unknown or unpreventable causes. Besides mechanical damage to the cable, such as direct piercing of the insulation which does sometimes occur, but not frequently, or to the conduit, which may admit moisture or water to the cable or into the connecting boxes, there are the more directly electrical faults, often due to electrolytic action or gradual decay. In the latter case the cause is generally supposed to be slow, unrestrained chemical action in the insulating material, which may not be of a stable character viewed in this light. Another class of faults of even more direct electrical significance is that including punctures and breakdowns due to so-called resonance and capacity or inductance effects. Dr. Fleming, in his recent Cantor lectures, and Prof. Forbes, in his lectures at the Royal Institution a year or two ago, have drawn special attention to the evils attendant on quick making and breaking. On the Continent, the Siemens principle of carbon makes and breaks as auxiliary to the principal steady and permanent contact in switches, has been adapted to those carrying large currents with success. In England, a favourite method is to make and break slowly by the introduction of impedance or choking coils between generator and mains. Thus at Deptford Mr. D'Alton and Mr. Geo. Partridge, in conjunction with Dr. Fleming, arranged transformers with variable water resistance on the secondary to act in this way, under the designation of a "main discharger." In other cases choking coils are cut in and out by multiple point switches, and this is a favourite device where alternating arcs on separate transformers are run from station bus bars. Should it be preferred, chokers with adjustable cores, or the excellent regulating transformers of Cowan and Still, might be utilised for the same purpose. The same object is sometimes had in view, but with a remedial and not a preventive sense when spark gaps are inserted across the ends of high pressure mains. Whatever steps be taken to guard against the acknowledged liability to trouble from pressure rises, it is not too much to say that the increasing attention devoted to the matter will have a direct return in reducing the number of mysterious breakdowns in insulation, and faults entered with the remark, "cause unknown."

ELECTROSTATIC INDUCTION AND THE SURFACE TENSION OF LIQUIDS.

In a paper in the *Physical Review*, for March—April of this year, Messrs. E. L. Nichols and J. A. Clark give an account of certain experiments made to determine the influence of a static charge of electricity upon the surface tension of water. The conclusion arrived at is, that the surface tension is considerably decreased by the presence of a static charge, the lowest value which the authors deduce from their observations being no less than 36 per cent. below the tension of an unelectrified surface. The results, as we point out below, appear to be open to more than one interpretation, and we are inclined to doubt whether the authors' experiments should properly be regarded as demonstrating a true reduction of surface tension with electrification.



Figs. 1 and 2.

The experiments were carried out as follows:—A water-dropper was constructed by attaching to the end of a burette tube, B, a piece of capillary tube, A, "upset" at the end until of about 1 centimetre diameter, and ground off to a plane surface so as to present a true circular disc. The water after passing through the capillary tube floated out upon the ground glass surface where it remained until a sufficient amount had gathered to form a drop. Fig. 2 shows the orifice with an adhering drop. The surface tension of the liquid was deduced from the weight of a drop, and to ascertain the accuracy of which the method was capable, some preliminary experiments were made in which 16 series, consisting of 20 drops each, were collected and weighed. The mean value of the weight of 20 drops proved to be 2·7706 grammes, and the average deviation from the mean of the 16 series was only 0·0026 g., or less than $\frac{1}{10}$th of 1 per cent.

The surface tension of water is a function of the temperature, diminishing in fact by nearly $\frac{1}{5}$th of 1 per cent. per

degree Centigrade, and as the observations extended over a period of three months, it became necessary to take a temperature calibration curve of the water-dropper, with the view of reducing all weighings to the same temperature. This was effected by the use of a German-silver and copper thermo-couple placed immediately beneath the orifice, the other junction being kept at boiling point in a beaker of distilled water. In this way the temperature of the drops was measured at the instant that they were detached from the orifice. The whole circuit, including the galvanometer, was well insulated, as during the experiments in which the water was electrified the thermo-element was brought into contact with the charged water at the instant of dropping. A galvanometer needle of sufficient weight to be unaffected by the static charge was employed. The calibration curve of the water dropper is given in fig. 3.

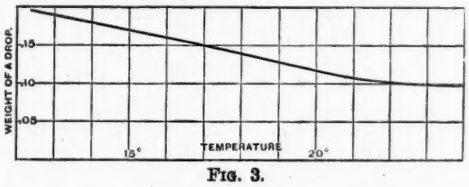


Fig. 3.

For the measurement of the potential an electrometer on the principle of the Henley quadrant electroscope was employed, consisting of a copper ball about 1 centimetre in diameter, suspended by a fine wire about 75 cm. in length, so as to rest against the centre of a vertical metal disc of about 30 cm. diameter. The ball and disc being both insulated and placed in electrical contact with the water-dropper the distance through which the ball was repelled when the water was electrified, was observed by means of a telescope. The maximum observed repulsion amounted to about 10 cm. A sufficiently light ball was obtained by electro-deposition of copper upon a leaden shot which was subsequently fused out. By immersion as an anode in an electrolytic bath, the weight of the hollow sphere was ultimately reduced to 0·142 gramme. The suspension wire, of No. 41 German-silver, was straightened by heating to dull red under tension.

In calculating the potential from the deflection of the ball the electrostatic surface tension was assumed uniform all over the disc, an assumption we may observe which for small deflections of the ball would reduce the calculated potential to nearly one half of the true value, since the surface tension at the centre of a circular plate is only one half of the *average* value over the plate. Making this assumption, however, the force on the ball becomes

$$F = q\,\sigma\,w,$$

where w is the solid angle subtended by the disc at the centre of the sphere, q the charge on the sphere, and σ the average surface density on the disc. Taking the capacity of the disc as $\frac{2R}{\pi}$, where R is its radius, and the capacity of the sphere as equal to its radius, and neglecting the slight reduction in the capacity of each owing to the presence of the other, the authors arrive at the formula :—

$$V^2 = \frac{\pi\, m\, g\, R}{4\,\rho\, L} \cdot \frac{a\,\sqrt{a^2 - R^2}}{\sqrt{a^2 + R^2} - a}$$

where V is the common potential of the sphere and disc.
m „ the mass of the sphere.
ρ „ the radius of the sphere.
L „ the length of the suspension wire.
a „ the distance of the centre of the sphere from the disc.
R „ the radius of the disc.

The authors state that "when the method of experimenting above described was put into operation, a number of interesting phenomena were observed. The first noticeable effect of charging the water was the change in the rate of dropping. Even with a very small charge this increase was easily noticeable. As the charge was increased, the size and shape of the drop could be seen to vary. The accumulated water on the disc of the dropper gradually became cone-shaped; and when the charge was further increased, this cone-shaped body of water broke up into three and sometimes four similar cones, from the apex of each of which issued a fine stream of water. These little cones stood out from each other like so many similarly charged gold leaves. While they generally retained the same relative positions to one another, they did not always remain the same with reference to any particular point on the disc. At times they were all found to be revolving around the central orifice of the disc, while at others they had a harmonic motion of slow period."

We have calculated the following table from the data in the paper.

Table I.

Potential in volts.	Weight of one drop corrected to 20° in grammes.
0	0·120
5,000	0·119
5,500	0·118
6,000	0·117
6,500	0·116
7,000	0·115
7,500	0·113
8,000	0·110
8,500	0·106
9,000	0·101
9,500	0·096
10,000	0·089
10,500	0·081
11,000	0·071

No absolute measurements of the surface tension were made, the tension at 20° of unelectrified water being taken as 72·5 dynes per lineal centimetre. This figure was obtained by applying Brunner's formula for temperature correction [$T = T_0(1 - 0{\cdot}00187\,t)$] to the mean of a table of 18 determinations of the surface tension at 0° by various observers. The following curve gives the authors' results as to the relation between surface tension and potential, but the method by which the value of the surface tension is deduced from the weight of a drop is not indicated.

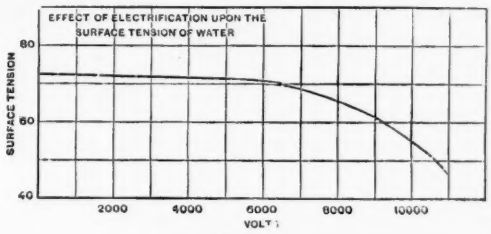


Fig. 4.

It will be seen that the surface tension diminishes slowly, but at an increasing rate with rise of potential, and that at 11,000 volts it has fallen off from 72·5 to about 46·6 in value.

The investigation concluded with a comparison of the effects of a positive and negative charge, in which it was found that there was no appreciable difference in the diminution of surface tension.

In considering these results we may first draw attention to the fact that the form of absolute electrometer used by the authors has the defect of being necessarily unscreened from external disturbances. Were it screened, its reading would be too high, unless the screen were of impracticably large dimensions. This defect in most instruments designed from the point of view of *repulsion* would perhaps be more clearly realised if the action were always regarded as one of *attraction*. In a properly constructed gold leaf electroscope, an instrument capable of approximate work as an electrometer between, say, 500 and 1,500 volts, a conducting case surrounds a pair of gold leaves, and on setting up a difference of potential between the case and the leaves the latter are attracted so as to open outwards. If the case is increased in size the attractive force is less for a given number of volts between the leaves and the case, and the divergence diminishes. If no definite conducting case is employed, the attractive force depends on the position of the instrument with relation to surrounding objects, and its readings are unreliable.

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Objection may also be taken to the expression of the results in terms of potential. The curve (fig. 4) gives us the relation between *volts* and surface tension. The potential of a body is not, however, in itself a physical property. When Faraday was conducting his famous experiments within the insulated cube, he and his instruments were all at a potential of some hundreds of thousands of volts above earth, yet no indication whatever of anything unusual could be observed. In electrostatic questions, as in the case of magnetism, the *strength of the field* is the important factor from the physicists point of view, and the authors' results should preferably have been expressed in terms of the surface tension, and the number of electrostatic lines of force per sq. cm. of surface. It is unfortunate that the conception of lines of force, which has been applied so successfully to magnetic phenomena, has not yet become equally familiar in connection with electrostatics.

But it is by no means clear to us that the authors' experiments indicate a true reduction of surface tension. The repulsion of the drops from the water-dropper will naturally produce a diminution in their size; they are thrown off like the electrified ink in the earlier patterns of Lord Kelvin's siphon recorder. The electrostatic effect is superposed upon the surface tension. An illustration will make our meaning more clear. In the case of a soap bubble, if T be the surface tension of the liquid, p the pressure of the air within the bubble, and r its radius, the equation which connects the quantities is :—

$$p = 2\,\frac{T}{r}.$$

Suppose, now, the bubble is electrified to a potential, V. It will expand, owing to the mutual repulsion of all parts of the surface, until the diminution of internal air pressure again brings things into equilibrium. The new condition satisfies the equation

$$\frac{V^2}{8\,\pi\,r^2} + p = \frac{2\,T}{r}$$

the surface tension now balancing the resultant of the internal air pressure and the forces of repulsion. A series of experiments in which V, r and p were observed, and T calculated, would place the question of its constancy or otherwise beyond a doubt, but the authors' experiments appear to us to afford no such test, failing as they do to separate the effects of electrostatic repulsion and surface tension.

DISSIMILAR ACTION OF SIMILAR MACHINES.

Under the above title Mr. William Baxter, jun., discusses in the pages of the *Electrical World* of New York certain small structural differences which, together, conspire to produce in machines intended to be identical considerable dissimilarity. The author points out that the difference in quality of materials and in dimensions, can never become zero unless absolute perfection is attained, and attributes the variations manifested in testing to small differences in the diameter and resistance of wire, and to differences in the magnetic quality of the iron used for armatures and fields. He states that charcoal iron is practically a thing of the past, and that 99 per cent. of all the charcoal iron in the market at the present time is *steel!* Amongst other things it is pointed out that differences in the air gap account sometimes for considerable variation in results, and that machines with small air gaps are most sensitive to these differences, as well as to differences in the magnetic quality of the iron. A case is mentioned where two armatures were made, one having a core of the highest grade metal, and the other a core of the cheapest stove-pipe iron obtainable. Though there was little difference in the permeability, there appears to have been great difference in the hysteresis loss, as the stove pipe iron got so hot that the current output had to be reduced.

That there are great differences in the quality of so-called soft iron sheets every maker of transformers knows. The permeability is not of paramount importance, but it is essential that the power which disappears as hysteresis loss should be as low as possible. All varieties of iron have been tried, and at times quite phenomenal results have been obtained. We know of a firm in the country, for example, who got the best iron they ever tried from a local ironmonger. They thought they had struck oil, but the quality of the odd parcel was never repeated. Once a learned professor applied to a large firm of sheet iron manufacturers for sample pieces of sheet in order to test their hysteresis loss. In due course the tests were made, and the professor applied for some more of the iron he had found best. But it was not transformer iron at all; it was not even ordinary armature iron; it was a variety which had been in stock for some years, out of which *tea trays were stamped!*

AN IMPROVED AUTOMATIC CUT-OUT.

The patent automatic cut-out illustrated by fig. 1 is being manufactured by Messrs. Williamson & Joseph, of 92, Queen Victoria Street, London, and embodies some very useful and novel features.

It combines two instruments in one, it being both a maximum and minimum cut-out, *i.e.*, it automatically breaks the circuit when the current either falls below, or exceeds a certain predetermined amount.

As shown by fig. 1, the switch is in the "off" position. When the handle is turned; the indentation in the curved projecting piece hitches in the small jockey wheel (which

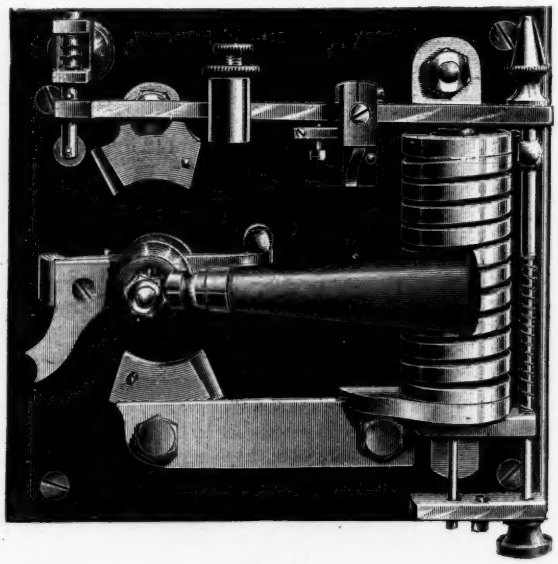


Fig. 1.

is kept pressed downwards by means of a spiral spring), and the switch is thus kept in the "on" position. If now the current passing through the electro-magnet (at the right of the fig.) increases beyond a fixed amount, its *top* armature becomes pulled down and knocks up the jockey wheel, and the switch handle being thus released, flies to the "off" position under the influence of a spring. Should the current have become weakened instead of increased, then in this case the *lower* armature falls away, and this, by means of the rod (shown parallel to the electro-magnet), pulls the top armature down with a jerk, and in this case also releases the switch handle.

One of the best features of the instrument is that the design permits of the use of an ordinary laminated brush switch of usual carrying capacity, thus assuring a good rubbing metallic contact in the most vital part of the apparatus.

Fig. 2 shows the cut-out adapted to, and combined with the starting switch of a motor.

If anything happens to the circuit of a motor, in which an ordinary automatic cut-out is placed, it is highly probable that the attendant would immediately replace the cut-out, thus starting the motor with full current on. This is impossible with the improved cut-out described. Should the current either exceed or fall below the proper limit, the starting

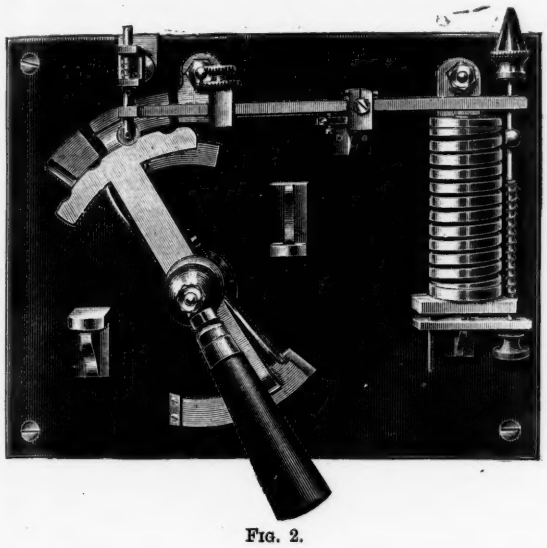


Fig. 2.

switch is released, the circuit broken, and it cannot be made again without going through the step by step replacement. The instrument is made with an arrangement for letting the switch stop at any particular point. They are made in all sizes, to carry from 25 to 2,000 amperes.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers.

Some Recent Developments in Electric Traction Appliances.
By A. K. Baylor. Read April 8th, 1897.

Generators.

In comparing a modern traction generating plant with one of seven or eight years ago, the most striking differences are found in the average size of the units in proportion to the station output, and the absence of belting or other medium of transmission between engines and generators. This may be largely accounted for by the change in public sentiment regarding electric traction during that period, and the greater confidence that investors have now in such enterprises. When electric traction first began to gain a foothold it was looked upon, like all innovations, as experimental and of doubtful value. As a natural consequence, all investment in plant was minimised. Small generating units were used, as the number of cars to be run was small. For the sake of economy in first cost, high-speed dynamos and slow-speed engines were generally employed, which necessitated the use of belts or ropes as a means of transmission. Now the conditions have changed, and in the design of power plants for traction work engineers are free to consider only what is best and most efficient in apparatus. Instead, therefore, of stations subdivided into small units, and filled with belts, ropes, counter-shafting, and clutches, we have in a modern plant a minimum number of separate units, and, with rare exception, the engine shaft carries the dynamo armature and is rigidly connected to it.

The first result of the call for increased sizes and greater mechanical efficiency was the introduction of multipolar instead of bipolar generators. Up to 1891 over nine-tenths of the traction dynamos in service were bipolar; to-day fully nine-tenths are multipolar.

Multipolar generators possess decided advantages over those of the bipolar type; they permit of better distribution of the magnetic material, and are lighter in weight, requiring less floor space for a given output, which is of especial importance when the output is considerable. Belted machines of the four-pole type were made up to 500 kilowatts, and this is still the largest standard unit of that class, for the reason that satisfactory commutation cannot be economically secured in four-pole traction machines of a greater output. The violent fluctuations of load, incident to such work, necessitate a fixed point of commutation, and experience has shown that the economical limit when this condition is fulfilled is reached at 100 to 125 kilowatts per pole on a 500-volt generator. Therefore the number of poles and the speed must vary with the output, the poles increasing in number, and the speed decreasing, as the capacity of the machine increases; so that slow speeds have become standard for all large traction generators, entirely apart from any consideration of the prime mover.

A very important step in the development of this class of machinery was the adoption of steel instead of iron for the field frames and pole cores. All first-class traction generators to-day are built of steel. By its use the magnetic properties of wrought-iron are obtainable, together with compact and complex forms of construction not possible with wrought-iron. Machines with steel fields require proportionately less magnetising force, and are of better efficiency in consequence, and a saving in copper in the exciting coils is effected, owing to the smaller cross sections of poles for a given effect. Steel machines are lighter also,

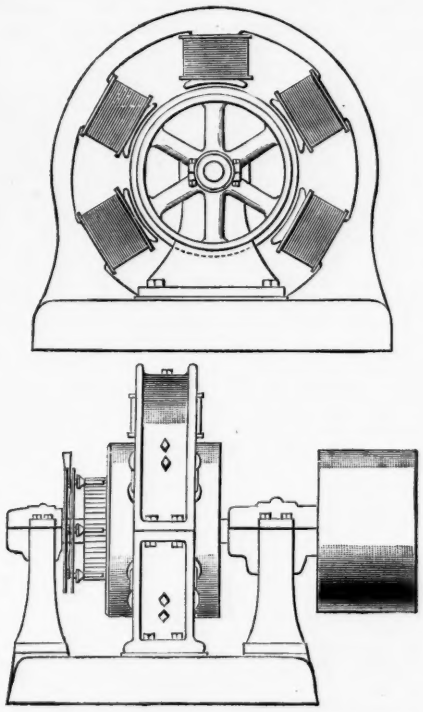


Fig. 1.—Typical Multipolar Traction Generator for Belt Connection.

and the consideration of weight becomes of great importance when the unit is a very large one. With a 1,500-kilowatt machine, for instance, the weight of the lower half of the steel field frame is from 16 to 20 tons. If this should be multiplied by about 2 or 2½, which would be the result of making the same machine of iron, the field castings would become decidedly unwieldy and difficult to ship or handle. This question is not so practically serious in small units, but, generally speaking, the lighter a machine is for a given output the better.

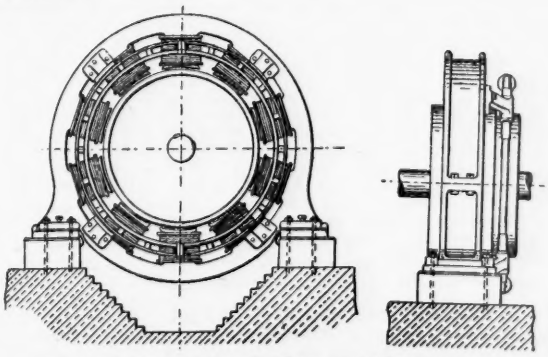


Fig. 2.—Typical Multipolar Traction Generator for Direct Connection.

Direct coupling was at first adopted only in the larger units, but this construction has now practically supplanted the older forms, and the sale of belted machines for traction purposes is now confined almost entirely to the smaller sizes, below 150 or 200 kilowatts. The severity of traction work led many engineers to protest against the rigid connection of engine shaft and armature. It was argued that the strain between short circuit and open circuit transmitted, without any medium for adjustment, to the engine would cause breakdown in a short time. To avoid this supposed danger flexible couplings were adopted, provided with various arrangements of spring cushions to absorb the strains; but all such devices have been found useless and unnecessary, and it has been demonstrated that with a properly pro-

portioned fly-wheel the interconnection of engine and dynamo presents no difficulty, such a fly-wheel being amply adequate to prevent racing on an open circuit or undue slackening of speed on a sudden overload.

The relative proportions of wheels vary with different engine builders, but average practice has shown the advisability of a wheel of such dimensions that it will carry the full load of the dynamo for about three revolutions, with a variation of not less than 5 per cent. in speed.

The method of connection between shaft and armature is different with large and small machines. In the former the armature spider is merely keyed to the shaft; but with large machines it is usual, in addition to keying, to bolt the spider to the arms of the fly-wheel at a diameter as far from the shaft as possible, in order to relieve the strain on key and shaft.

As a precaution against bursting, the built-up type of fly-wheel has been used in some few cases for direct coupled traction units. Fig. 3 shows the detail of such a wheel. As will be seen, it is made up of segments bolted and riveted together. This construction, of course, permits of a relatively greater peripheral speed than is safe with the ordinary cast-iron wheel, but the cost is increased about 25 per cent.; and with a proper safety check upon the engine for cutting off steam at any predetermined increase of speed, danger of accident with cast wheels my be amply guarded against.

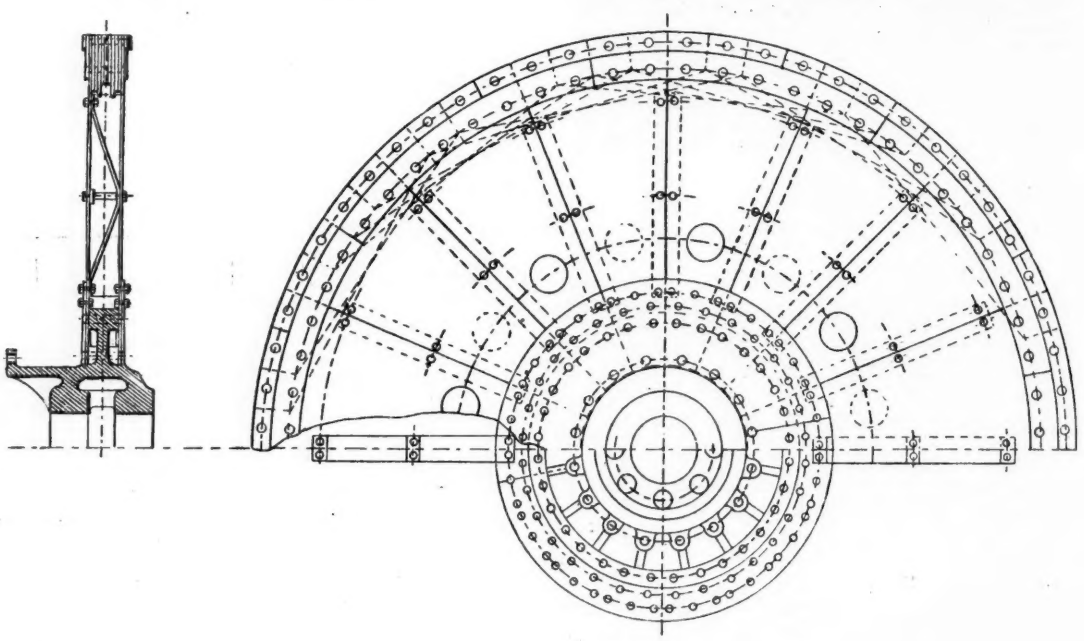


Fig. 3.

There are many points of commercial advantage in favour of direct-connected, as compared with belt- or rope-driven, generators that appeal to those interested in investment and operating expenses. The efficiency of a given plant is increased by direct coupling, and its operating expenses are decreased. The friction losses due to the use of belts or ropes will average about 5 per cent. of the indicated power of the engine at full load; and, as this loss is a practically fixed quantity, the percentage of loss increases as the percentage of load decreases. Unless, therefore, the running units can be kept at approximately constant full load—which is possible only when the number of independent cars or trains in service is very large, or the stoppages and starts infrequent—these losses will exceed the minimum, and may be taken as about 8 per cent. in average practice. In operation, a substantial economy is gained also by the reduced number of bearings and wearing parts, by a saving in maintenance of belts or ropes (to say nothing of their first cost), and the possibility in general of running with a smaller staff for a given plant output.

As affecting total cost of plant, the reduced floor space occupied by direct-coupled machinery becomes a factor of much importance when it is desirable to locate the generating station in a district where land values are high. Again, the buildings may be smaller, and therefore less expensive, and something may be saved in foundations.

There are undoubtedly some engineers who still consider the direct coupling of traction units unsafe practice, but the 300,000 horse-power (or thereabouts) of such machinery now in regular and successful operation ought to remove their doubts.

Compared with old-style machines, a modern traction generator is highly economical in operation, both on account of its greater efficiency and its lower cost of maintenance. The efficiency and the cost of maintaining apparatus are the true measures of its superiority and value. First cost should be a secondary consideration, unless the machines are intended for exhibition purposes and not for service. Unfortunately, this order of things is usually reversed, and the selling price too often settles everything, without regard to the expense for fuel, maintenance, and repair that the use of poorly constructed (and naturally cheap) machines may lead to.

In this connection it is to be borne in mind that, as a rule, dynamo ratings are arbitrary. With engines where the cylinder dimensions, steam pressures, speed, and economical point of cut-off are given, tests will establish accurately the rating that may be assigned to a given machine; but in dealing with generators and motors it is, unfortunately, common practice to give only the rating in horse-power or kilowatt capacity—a figure usually dependent on the conservatism, or otherwise, of individual engineers. The temperature which will be developed in the conductors or any other part of the machine in a given number of hours' running at a given output, and the sparking limit, are too often omitted. There is certainly no reason why dynamos should not be as specifically rated as the engines which are to drive them. A standard should be adopted covering sparking and temperature limits, so that all dynamos would of necessity be rated on the same basis, and the rating indicate accurately the capacity of a machine for service. The absence of such a standard puts a premium upon over-rating, as selling prices are based on rated output.

In the economy of a plant much depends upon the stability of the generator armatures, and the development of this feature of modern machines has been most interesting. Compared with the drum windings common in the early bipolar types, or the ordinary ring winding used formerly in the multipolars, the present standard armature construction is extremely simple and durable. The main object of engineers who have followed this work has been to produce an armature mechanically and electrically strong to guard against breakdown, and mechanically simple to permit of ready access and easy repair should an accident occur. Properly speaking, a modern armature is not wound, but built. The conductors do not consist of wire, but solid bars formed to shape before they are put in position.

The greatest cause of burn-outs and grounds in the old wire-wound armatures was the shifting of the windings due to twisting and centrifugal strains, and this sort of trouble was especially common on smooth cores. It was impossible to readily provide proper radiation for the inner coils on such armatures, more particularly those of the drum type, and the indiscriminate crossing at the ends of conductors of considerable potential difference was another source of trouble.

Breakdowns from these causes are now pretty much done away with. Shifting of the conductors is impossible, as they are embedded in slots in the core, and bound firmly in place; and in the latest construction all the end connections or wires outside the slots, instead of being bent down against the core, are extended straight out parallel with the shaft, and supported by cylindrical extensions from the spider at a diameter equal to a circle cutting the base of the core slots. When the winding has been properly disposed, it is carefully covered with insulation, and bound in place with binding wires across the core face, and out over the cylindrical end supports. The leads to the commutator are taken off at the extreme edge, leaving the conductors proper a compact cylinder like the rim of a pulley wheel, and nearly as substantial, presenting on the outside a smooth surface upon which dust and grit cannot collect, and protected fully on the inside by the core and the spider extensions.

The task of replacing a damaged coil in such an armature is comparatively simple, and rupture of the insulation seldom occurs, as the coverings have little tendency to deteriorate when the conductors

cannot shift or vibrate, and when wires of great difference of potential are kept well apart. Destruction by heating is guarded against by ample use of copper in the conductors, and by ventilating ducts through the core. The lateral extension of the end connections, as described, provides also excellent means of radiation, and this arrangement of conductors reduces the length of wire at the ends to a minimum, effecting an economy in copper and an increase in efficiency.

A practical advantage of much importance gained by this method of armature construction is that it effectually guards against damage due to careless workmanship. In constructing an ordinary wire-wound armature, a careless winder may so abrade the covering of the wire, that its insulation will be ruined. With the construction described, on the contrary, each coil or section is made up, formed, and insulated separately, and carefully tested for any imperfection. The separate sections being shaped by die before being placed on the core, assembly is a simple matter, and is attended with little or no danger to the insulation.

In commutators the chief development has been towards better mechanical construction. On the best machines the commutators are built in sections, so that separate parts may be removed and renewed without disturbing the balance of the commutator—a matter of great convenience on a large machine.

Switchboards.

In modern practice the panel system is almost universally used in dealing with the switching and controlling gear of the station.

The panels are usually slabs of polished slate or marble (wood being no longer sanctioned), upon which the necessary instruments are mounted so that each panel, whether for the control of a generator or a line feeder section, is complete in itself. By following fixed dimensions, and a regular arrangement of instruments and switches, any number of these panels may be mounted side by side, forming when interconnected a complete and simple switchboard. This practice is largely the result of the constant additions that have been necessary in almost all electric traction plants, and the desirability of increasing the capacity of a station by the addition of new machines and controlling gear without disturbing the instruments already installed, preserving at the same time the appearance and uniformity of the switchboard as a whole.

In the principle of switchboard arrangement there has been little or no change, except as to the main switches.

Formerly it was the usual practice to mount the positive, negative, and neutral switches on a common yoke, and throw them in and out of circuit simultaneously by a single handle. It was then necessary, in putting a generator on the line in parallel with other machines already running, to build up its field with the shunt excitation only, to a point something below the station voltage, so that when the positive, negative, and equalising switches were closed the additional field due to the series coil coming into action would bring the machine up to station pressure. It required some care on the part of the operator to determine how far to carry the shunt excitation so as not to fall below or exceed the station potential when the main switches were closed. Even with the greatest care there was always the danger of a fluctuation in the voltage of the running machines at the instant of closing. To prevent any tendency to motoring or flashing at the brushes, when throwing machines into parallel, the main switches were separated, so that each could be closed or opened independently, and this arrangement is now followed in practice. With separate switches it is possible to run the generator up to full voltage before throwing it into circuit by building up the shunt field and then closing the positive and equalising switches, thus putting the series coil into parallel with the series coils of the running machines. In order to connect with the line it is only necessary to close the negative switch, and the load will divide smoothly, the voltage being already balanced.

A further practical advantage is gained by this arrangement in that less time is required to build up, due to separate excitation through the series coil. It also prevents the fields coming up at opposite polarity to those on the machines in operation.

(To be continued.)

Physical Society.

Ordinary Meeting, April 9th, 1897.

Mr. Shelford Bidwell in the Chair.

Mr. S. A. Garrett read a paper on A Nickel Stress Telephone.

In conjunction with Mr. W. Lucas, the author has experimented upon telephones with nickel magnets. A magnetised nickel rod is wound with insulated wire, and is then fixed vertically by a clamp at its lower end. A wooden diaphragm is rigidly attached to the top of the rod in a horizontal plane. The rod just passes through the middle of the diaphragm where it is fixed with sealing-wax. The diaphragm is entirely supported by the nickel rod. On speaking against the top of the diaphragm, variations of longitudinal pressure, and consequently of magnetisation, are produced in the nickel; and corresponding undulatory currents are induced in the surrounding coil. The nickel wire is sometimes magnetised by stroking it with a magnet, and sometimes by passing a current through the coil. A diaphragm of pine wood gives better results than a metallic plate. The instrument does not work well as a "receiver;" an ordinary telephone is used for this latter purpose. The results obtained with a weakly magnetised nickel rod are much better than those with a strongly magnetised steel rod, indicating that the undulatory currents are due rather to magnetic variations arising from changes of stress than to the relative motions of the magnet and coil.

Dr. S. P. Thompson said that some years ago he had worked with a somewhat similar apparatus, using it as a "receiver," with wires of nickel, cobalt, and iron. Cobalt gave the best results; the metallic strips in his experiments dipped into the solenoids without contact with them. This arrangement did not work well as a "transmitter," even when a battery was included in the circuit. In some cases the rods were cut into short lengths separated by brass.

Mr. Boys asked how the nickel "stress" instrument compared in clearness and loudness with an ordinary telephone.

Mr. Shelford Bidwell had tried a nickel telephone with a mica diaphragm, depending not upon mechanical stress, but magnetic strain. It did not work well.

Dr. Chree thought the "stress" telephone might possibly be improved by choosing the right strength of magnetic field.

Mr. Appleyard said the arrangement was interesting historically, because it was, mechanically, almost identical with the original instrument used by Philip Reis as a "receiver." The authors had succeeded in getting it to work as a "transmitter." Their success was probably due to the rapidity with which the magnetisation of nickel responded to very small charges of stress or current. The Post Office electricians had tried to introduce nickel cores into relays, on account of its magnetic sensitiveness; the results, he believed, had not been very satisfactory.

Mr. T. A. Garrett, in replying, said the "stress" telephone gave better articulation than an ordinary "watch" telephone, but the sounds were feebler. There seemed to be a field-strength proper to the instrument; he had noticed that the articulation was clearer with three cells than with six.

Mr. W. A. Price then read a paper on Alternating Currents in Concentric Conductors.

This is a mathematical investigation of a proposed new form of submarine cable. The case is considered of two concentric conductors, interrupted alternately at different points throughout the whole length. In the mathematical treatment the cable is supposed to be laid in a circular path, and successive charges of electricity are supposed to be applied at some point at the extremity of a diameter of the circle. Expressions are given for the amplitude of the periodic charges arriving at a point diametrically opposite to the first, and for the reduction in amplitude throughout the whole length of the cable of an applied E.M.F. The theory indicates that under no circumstances can the "speed" of a cable of the proposed form be greater than the "speed" of a cable of ordinary type. The author has experimented upon an artificial cable connected up to represent the proposed form. The "definition" of signals is considerably better than that obtained through an artificial cable of analogous "weight" and "length" connected up in the ordinary way. Within certain limits the "definition" continues to improve as the number of sections or subdivisions of the cable is increased.

Mr. Blakesley said he was sorry the result did not indicate a successful type of cable. He would have been inclined to predict that the amplitude would have decreased with the number of sections. If a number of condensers were joined in series, and one end was subjected to a periodic E.M.F., the amplitude would fall off inversely as the square of the distance.

Mr. Price then exhibited a galvanometer support. The instrument was suspended from two India-rubber cords attached at the top and bottom to cross-bars of metal, thus forming a rectangle. The cross-bars were provided with knife-edges in such a way as to compensate for unequal stretching of the India-rubber. Weights could be added, if necessary, to the support, so as to increase its inertia.

Mr. H. Garrett read a paper, communicated by Prof. W. B. Morton, on The Effect of Capacity on Stationary Electrical Waves in Wires.

The author investigates the effect produced when a condenser is inserted at a point in the secondary circuit of the apparatus used by Blondlot for obtaining stationary electrical waves in wires. The positions of successive nodes are determined in the usual way, by a bridge with a vacuum tube indicator. When two opposite points of the parallel secondary wires are joined to the plates of a small air condenser, the nodes approach the condenser on either side. The amount of the displacement of the nodes, that is to say, the extent of the shortening of the apparent half wave-length, depends upon the position of the capacity along the wires. The effect is *nil* when the condenser is at a node; and a maximum when it is midway between two nodes. The state of affairs at a point of the circuit is obtained by summation of a series of separate disturbances due to the different direct and reflected trains. In obtaining a formula for the conditions of resonance with which to compare the observations, the author adopts a method from Heaviside. It connects the frequency of oscillation with the position and capacity of the condenser.

Mr. Shelford proposed a vote of thanks to all the authors, and the meeting was adjourned until May 14th.

THE MANUFACTURE OF TUBING.

The use of iron or steel pipes for conduits for electrical conductors has become so extensive in these latter days, says the *Electrical World*, that a description of the principal concern manufacturing these goods will be of interest at this time.

The National Tube Works Company, McKeesport, Pa., is said to have the largest establishment of its kind in the world. The plant is located just below the junction of the Youghiogheny and Monongahela Rivers, in the State of Pennsylvania, directly on the bank of the latter stream, and occupying over 100 acres of ground.

The company was started in Boston in 1865, and in 1872 its works in McKeesport were put into operation. The works of the company at the present time extend for a mile along the bank of the Monongahela River, and from 9,000 to 10,000 men are employed in all departments. The annual capacity of the National Tube Works Company of tubular goods is over 250,000 tons, and its product goes to all parts of the world, including England, which has hitherto been considered the home of the iron and steel industry.

A faint idea of the magnitude of the operations of this company may be obtained from the fact that over 900,000 tons of coal are consumed at the plant every year, requiring for its delivery coal cars which, placed end to end, would cover fully a mile, this great number of cars being admitted to the yards every day in the year.

The product of the company includes gas, hot water and steam pipe, pipes for conduits for telegraph, telephone and electric light wires, underground and interior work, street railway conduits, &c., besides water-works mains and pipes of every description and for every use.

To obtain the best results in the production of its goods, the National Tube Works Company, in 1892, built a complete steel plant near its blast furnaces, thus placing itself in a position to control every stage of the process of manufacture from the raw iron ore to the finished tube or pipe. Every particle of iron or steel which is employed in this establishment receives the most careful and systematic inspection, to the end that the best obtainable results may be had and the best satisfaction to patrons guaranteed.

The prime requisite of the special mild steel made by the National Tube Works Company is that it shall produce pipe which will weld so that the weld will be at least as strong as the body of the pipe itself, and which will take a perfect thread and possess flanging qualities as good as those of the highest quality of Swedish charcoal iron. These results are obtained in the pipe mill, where are located several welding furnaces, and the necessary cutting and threading machines, besides testing benches, &c.

The skelp (thin strips of rolled steel varying in width, length and thickness) after having been bevelled on its edges is pushed into a welding furnace and subjected to a welding heat. It is then passed over a mandrel and through a pair of welding rolls, which press down the lap and form the mass of metal into an even cylindrical form. The pipe, then in its rough state, is passed through sizing rolls and afterwards straightened in dies controlled by hydraulic power. The rough ends are then cut off, threads cut, a coupling is screwed on and the tubes are inspected, after which they are ready for the market.

Over 1,000 different sizes of tube are produced at these mills, ranging in diameters from the ⅛-inch gas pipe to the 24-inch water, gas or oil main. The aggregate horse-power required in all the departments of this vast industry is 20,000, and the business requires the constant use of 12 locomotives and 500 cars in the transportation of material between the different departments during the process of manufacture.

The National Tube Works Company maintains sales offices at New York, Pittsburg, Chicago, Boston and St. Louis, and is now establishing an office at London, England, where its foreign trade will be looked after.

CORRESPONDENCE.

Colwyn Bay Electric Lighting Scheme.

I am very pleased to see in your issue of April 2nd Mr. Bennett's letter of March 25th, anent the Colwyn Bay electric lighting scheme.

Publicity in the engineering papers can with advantage be given to the methods adopted in this competition, on the ground that it is of interest to local authorities generally, and to the profession in particular, as a guide and warning in the procedure of future open competitions.

It is from this standpoint alone that I venture to trespass upon your valuable space, for I am one of the majority who has not drawn the winning number; therefore it will be uninteresting to your readers, and a waste of time for me, to criticise rival schemes.

Mr. Bennett has put the facts very clearly. However, I wish to emphasise the fact that the proposals were essentially a combined scheme of electricity supply and refuse destruction, the Council having practically decided to lay down a refuse destructor apart from the question of electric lighting. On looking carefully into the matter, it was found on economical and other grounds advantageous to combine the schemes—a suitable site being already available. This point, by the way, is important only in judging of the outlay proposed in the selected schemes.

The competitors, on comparing notes, have been much struck with the great divergence in the information obtained as to the Council's requirements. In addition to the requirements set out in Mr. Bennett's letter, some of the competitors understood it was necessary to provide offices and dwellings in the proposed buildings, while others did not get all the items mentioned by Mr. Bennett. In fact the greater efficiency in pumping qualities brought out additional requirements, with the inevitable result of increasing the outlay proposed and handicapping the competitors.

There were no printed particulars of Council's requirements issued, hence arose the above uncertainty under which the competitors laboured, and the impossibility of an adjudicator knowing upon what conditions the various schemes were based.

As regards the extension of time, of course a Council are quite within their rights in granting an extension once, twice, or as often as they wish, if they deem it advisable. As a fact the time was twice extended in this case. Unfortunately, however, the notices were not given in time to prevent some of the competitors sending in their schemes to the Town Clerk by the original date, viz., January 12th, apparently. In *Lightning* of January 14th I see against a Colwyn Bay note that several schemes were sent in with regard to the electric lighting of the district.

This is manifestly unfair; the additional time granted might have enabled greater elaboration to be given to the preparation of the schemes.

The competitors were informed that the Council was anxious that an impartial assessor should consider the schemes, and that the expert would be appointed who received the greatest number in nominations. This was an eminently wise and fair method of treatment towards competitors, and might with advantage be copied in future competitions.

Subsequent reports in the local press appear to show, however, that as regards votes the course foreshadowed was not adhered to.

Then as regards the adjudicator's report. It is difficult to understand why the adjudicator's first award was set aside.

Commenting upon the figures of the schemes given by Mr. Bennett, your readers will be the best judges; but I have yet to learn that the whole of the Council's requirements can be provided for by an outlay of only £7,450, or £55 per kilowatt capacity, bearing in mind the provision of a refuse destructor, buildings to include offices and dwellings, shaft sufficient for all future demands, power for traction and pumping, &c.

The area of supply is extensive, and includes Colwyn Bay and Colwyn, although naturally the compulsory streets are in the first instance more limited in extent. Many of the residences and hotels are widely scattered. The writer could not, even by proposing an alternating current scheme, get a figure so low, while meeting the Council's requirements.

The majority of the competitors are unanimous in a strong feeling of resentment at the unsatisfactory turn of events.

I trust that the ventilation of the points under discussion may tend to prevent a recurrence of similar methods in future competitions.

W. Howard Tasker.

April 7th, 1897.

Commutatorless Continuous Current Dynamo.

In reply to Messrs. De Puydt & Poncin's letter in last week's Electrical Review, I should esteem it a favour if you would allow me to draw the attention of these gentlemen to your article "On the Mechanical Conceptions of Electricity and Magnetism," wherein they will find an answer to the first point upon which they very courteously invite an expression of my opinion.

With regard to my views on the subject of electromagnetic phenomena in general, I fear it would be of no help to Messrs. De Puydt & Poncin if I were to air them here; and this more especially, as their methods of reasoning and my own appear to me to have very little in common. They will, however, find much that is interesting, and even (possibly) instructive, in the writings of Maxwell, Du Bois, and Prof. Ewing—(to give only a few names)—for these scientists, having all dabbled somewhat in this subject, the explanations they have given of *observed* phenomena are considered by a large number of intelligent persons to be, on the whole, sound.

I think it would not be right to take up any more of your valuable space in discussing questions which can be of no interest to your readers. Messrs. Du Puydt & Poncin, I have no doubt, will agree with me here, and, for this reason, they will forgive me if I do not reply at greater length to the remarks consequent upon their perusal of my last letter.

X. Y.

Country House Lighting.

It may be of interest to some of your readers to know that Mr. A. H. J. Graham's figures of 15 lamps of 16 C.P. from one brake horse are not all out of the way for running direct if you use high efficiency lamps. I know of two installations, one of 24 16-C.P. lamps run at 40 volts, the other of 65 16-C.P. lamps run at 60 volts; the former plant consists of a ½-horse nominal gas engine, 900 watt dynamo and 22-K 7 cells, the other of a 4-horse nominal gas engine, 3,600 watt dynamo, and two sets of 33-K 11 cells used in parallel; in both cases lamps using 2½ watts per candle-power are used, this being equivalent to 16 lamps per brake horse-power when using an 85 per cent. efficiency dynamo; the life of the lamps are short compared with 60-watt lamps, but this is hardly noticed in house lighting. In the first case taking three years of service, the average is six new lamps a year, in the larger installation an average of four years is about 10 lamps per year.

The gas bill for the ½-horse engine averages £6 10s. per year, and that for the 4-horse £9 10s.; in the smaller installation an electric kettle and saucepan are used fairly often, gas in both cases being 2s. 9d. per 1,000 cubic feet.

The small engine probably takes 30 to 35 cubic feet of gas per B.H.P., including the ignition bill supply as compared with 20 to 25 cubic feet in the larger engine. The gas bill for lighting the houses previous to the installations was £7 and £19 respectively per year. In the above two cases direct running is never resorted to; in the smaller plant the cells are usually kept charged between ½ and ¾ full, which I find brings up their watt efficiency, and being only subject to a low discharge rate, does not seem to have any ill effect on them; the last ¼ charge seems to take about 3 volts per cell, and allowing 85 per cent. ampere efficiency, they would only give out about 55 per cent. watt efficiency.

It seems from the above figures that the over-all cost of running is, for a small plant, on a par with gas, and on anything larger than the smallest, considerably less; the interest and depreciation on the plant is usually more than covered by the saving on furniture, fittings, and paper; the ratio, of course, depending on the style of house fittings, pictures, books, &c. The larger of the above plants is looked after by the gardener, and the smaller one by one of the maid-servants, a starting switch being provided, and the dynamo used as a motor to start the engine.

As Mr. Davenport says, acid does not form an important part of the working cost; 6d. would pay for all the acid used in both houses in three years; oil comes to about 12s. per year for each plant.

As regards running direct on a 250-light installation, using 60-watt lamps, a 16 horse nominal gas engine, and a 250-light dynamo, when the plant was new, we got one 16-C.P. lamp for every 1·7 cubic feet of gas at full load. This was verified over and over again. After about two years running (five hours every night) this increased to 2·0 cubic feet. The engine was then overhauled, and new piston rings put in, and the amount of gas went down to 1·7 cubic feet again.

With reference to the 8-C.P. lamp being the trade understanding of the word lamp, how would a case be ruled in this district, where an 8-C.P. lamp is practically unknown either to the trade or to purchasers? **Percy Rosling.**

Re Interior Conduits.

In the article quoted from the *Electrical World*, and also in the correspondence in this matter, a great point against the use of plain iron tubes is made of the fact of roughness in the interior of tubes and the burr at cut joints.

Surely this is a matter which can be got over without it being necessary to line the tubes. Cannot tube makers rise to the occasion and give us something approximating to a smooth tube? The burr on the end of a cut tube is a matter that is easily got over, and is, in fact, got over daily in other cases than tubes used for conductors.

There must be several miles of iron tubes from ⅜ upwards in use for electrical purposes, which have been laid for some years, not only for electric light but for telephones and bells, and if we used to get over the matter of rough tubes in days gone by, why not now?

The writer has under his charge a considerable amount of wiring in plain iron tubes, and up to the present finds it the most reliable part of the whole installation.

The work is carried out with just ordinary tubes and fittings, and so arranged that there are no joints whatever in the system. This can be carried out generally with a little management, and the extra cost of conductor is compensated for in saving of time, &c.

Choose good tubes, clean the burr off the ends, and see that no grease or oil runs down the tube when screwing, and make joints with shellac, varnish, or gold size. Use good quality cable, the writer uses okonite; avoid joints, and you will do work that will compare favourably with an insulated conduit as regards efficiency, and be far before it in the matter of cost. **Plain Tube.**

[Correspondence.—Owing to pressure upon our space this week we are compelled to hold over until next week several original and interesting communications from correspondents.—Eds. Elec. Rev.]

COST OF ELECTRICITY AT BRIGHTON.

We have frequently called attention to the extremely low prices at which many consumers in Brighton obtained their electricity, and the following table, which is being distributed by Mr. Wright, shows how favourably electricity at Brighton prices compares with gas when there is a considerable consumption of current:—

Table showing how the Cost of Electricity in Brighton Diminishes with the Lengthened Daily Use of the Light.

Class of rooms and premises in which the lamps are used.	Average number of hours the lamps are used per day.	Total number of hours the lamps are used per annum.	Usual time of extinguishing lamps lighted at dusk.	Average rate charged per unit consumed during the year.	Equivalent cost of gas used in ordinary burners per thousand cubic feet.	Annual cost of electric and ordinary gas burners giving 8 C.P.		Amount saved per annum on each 8 C.P. lamp by use of electricity, exclusive of saving in redecorating, &c.	Time in which the cost of fitting up the electric light will be repaid by the saving effected, due to its lesser cost and extreme cleanliness.
						Electric lamp including renewals.	Ordinary gas burner with gas at 2/9 per 1,000 cubic feet.		
					s. d.	s. d.	s. d.	s. d.	
Offices, early-closing shops, and occasionally used rooms.	1	365	7 p.m.	7d.	4 1	5 10	3 11	.....	.....
Shop windows	2	730	8 „	About 4¼d.	2 6	8 1	7 10	.....	.....
Interiors of shops	3	1,095	9 „	„ 3⅜d.	1 11	9 4	11 9	2 5	2½ years.
Sitting-rooms, halls, kitchens, basements, and late closing shops.	4	1,460	10 „	„ 2⅝d.	1 8	11 1	15 9	4 8	2 „
Hotels, restaurants, and public houses.	5	1,825	11 „	„ 2⅜d.	1 6	12 10	19 8	6 10	19 months.
	6	2,190	12 „	„ 2¼d.	1 5	14 1	23 7	9 6	16 „
Clubs and billiard rooms ...	7	2,555	1 a.m.	„ 2⅛d.	1 4	15 10	27 6	11 8	14 „
	8	2,920	2 „	„ 2d.	1 3½	17 10	31 6	13 8	12 „
Outside lamps, dark business premises and basements.	11	4,015	Dawn, or used all day long.	„ 2d.	1 2	22 4	43 3	20 11	9 „
	24	8,760	Continually used day and night.	„ 1½d.	1 0	42 7	94 2	51 7	5 „

LEGAL.

Hookham *v.* Johnson.

Judgment.

On Saturday (10th inst.) Mr. Justice Wills delivered judgment in this action of Hookham *v.* Johnson, in which Mr. George Hookham, of the firm of Messrs. Chamberlain & Hookham, electrical engineers, of Birmingham, brought an action against Messrs. Johnson & Phillips, electrical engineers, of London, for alleged infringement of letters patent granted to plaintiff for inventions and improvements in electric light meters. The case, as reported in the Electrical Review recently, occupied the Court seven days. Mr. Fletcher Moulton, Q.C., and Mr. A. T. Walter and Mr. Gray appeared for the plaintiff, and Mr. Bousfield, Q.C., and Mr. Graham for the defendant.

His Lordship, in the course of his considered judgment, said: I do not think it necessary to go elaborately through the body of the specification in order to ascertain the meaning of the first claim, which seems to me to be abundantly clear. In the first place the drawings are, in my opinion, referred to not to confine the claim to one form of apparatus which they graphically describe, but to give a perfectly definite description of that one form of apparatus, and to illustrate at once the principle and method of combining electromotor and brake, both in constant and powerful field, and preferably both using the same field. It is emphatically a combination claim, in which all the elements described in the specification, and illustrated in the drawings are to be found together. These seem to include:—(1) An armature of any known type with a constant field; (2) the use of a powerful field for the electro-motor, and also for an electric, or, perhaps, it would be more proper to say, a magnetic brake; (3) the application of a permanent magnet in the form of a ring as nearly complete as possible, only interrupted by the narrowest possible interval with large pole pieces on each side of the interval, so as to afford ample facilities for passage of the lines of magnetic force, and to reduce to a practical zero the lines of magnetic force during the passage of the magnetic flux through the air, the pole pieces being so arranged for each revolution of the armature that its passage into and out of the magnetic field shall involve giving rise to Foucault currents, whose action constitutes the braking power. I have purposely, for the sake of simplicity, missed one or two contemplated variations. For instance, the one constant field may be replaced by two, and the permanent magnet by an electro-magnet, but these matters do not affect anything I have to say at present, and for the sake of simplicity may, for the moment, be left out of my statement. Further, there is a clockwork arrangement for registering the number of revolutions of the armature, but as except in one small maker forming the subject of a subordinate claim (it is a well-known type), I do not at present propose to say anything about it. The first claim makes no reference to it, and it is with the first claim only that I proceed to deal. Most of the above elements of the invention appear so clearly on the face of the specification, that I need only state them. The necessity for a magnetic field appears clearly enough also, though it is not so specifically stated as one might expect. The work done by the motor, and the resistance offered by the magnetic brake, are in direct proportion to the speed of rotation. Friction, in being reduced so low as possible, varies nearly as the square of the speed of rotation, hence it will be a seriously disturbing element, unless it can be made negligible. This can be done by exaggerating the other forces as compared to it. Hence the necessity for a powerful field. If it be so powerful that friction may for practical purposes be overlooked, the speed of rotation will then and there only be directly proportional to the armature current. I gather all this from the specification, and without any evidence except that friction varies at a higher rate than the speed of rotation. To my mind, and whatever the consequences with regard to novelty or to sufficiency of specification, the application of this combination for all ordinary forms of electro-motors is clearly within the claim. In the "description," we have the electric motor well known at the date of the patent having the cup armature, and the cup armature is, therefore, included in the claim. I emphasise this, because the alleged infringement has a cup armature; and the first objection that had been taken to the specification is that it contains no specific directions which could enable a workman to make a meter adapted to a cup armature. The apparatus described in the patent is shown bodily in the exhibit, G.H.I. Nothing turned upon the details of the electro-motor, I do not gather from the patent that any particular stress is laid upon them, inasmuch as any inference of that kind is qualified by the general statement that "the electric motor may be of any of the ordinary forms now in use," which implies that any known type of the cup armature will do. Now the cup armature involves a total departure in externals from the form given in the drawing, and the real question is whether the workman who has the drawings G.H.I. could without experiment adapt them to an apparatus of the type of J.J.I., the alleged infringement. It seems to me that the skilled workman could not help seeing that he had to arrange his permanent magnets so that one group of them should end in a pole piece or pole pieces coming up inside, and the other group with the corresponding pole piece or pole pieces coming up outside the cup, I do not see how he could do this except by placing them at some little distance apart from one another, the one group forming a bundle in the middle and the other forming a ring or circle in the cup, the pole pieces respectively inside and outside the cup being brought as near to the inside and outside of the cup as they could be brought without impeding the rotation of the armature. It seems to me that thus the very necessities of the case would suggest all that was absolutely necessary. Let us suppose that the north ends of the interior group of magnets and the south ends of the exterior group are those which rest on the floor of the cylinder which must include them all. The slight mechanical arrangement by which the south ends of the exterior group would have to be connected with the north ends of the interior group, and by which the south ends of the interior group should be brought to a magnetic focus, so to speak, in the south pole piece of the interior group, and by which the north pole piece outside the cup should be made the magnetic focus at this end of the exterior circle, the bar magnets seems, as it seems to me, to be perfectly within the grasp of a mechanical engineer skilled in this kind of work. The necessity of keeping friction low would prevent him from making the cup too large. The necessity for strong braking action would prevent him from making it too small, and I cannot, in spite of my respect for the witnesses who have expressed opinions to the contrary, bring myself to entertain serious doubt that, notwithstanding the great and manifest differences to the eye in the two sets of apparatus, there would have been no great difficulty in constructing a working machine of the J.J.I. type by a skilled workman who had before him G.H.I., or the drawing, which very fully and accurately described that apparatus. I think it is also impossible to doubt that such a skilled workman would have known that his pole pieces must neither of them be continuous all round the circle, of which they must necessarily form part, as he would know that if they were continuous there would be no braking action at all, and that subject to allowing a sufficient space of discontinuity, if he need more than one of them, should give as large aggregate areas as possible. I think I see where I and the defendants' witnesses upon this point diverge. I think they have been speaking with the apparatus J.J.I. in their minds just as it stands, and I have no doubt that with respect to many matters of nice adjustment and proportion, so as to get the best result, they are right enough. I still retain my opinion that a skilled workman would have adapted G.H.I. to the cup armature, and made without experiment a working machine, though probably not so good a one as J.J.I. This objection, therefore, fails. Other objections have been taken to the sufficiency of the specification, but so much light will be thrown upon them by a discussion of the important question as to the novelty of the invention, that I propose now to address myself to that question. In doing so, it must be borne in mind that I consider this to be a patent simply for the combination described. It is urged on behalf of the defendants that there is nothing in the combination that is new and specifically an anticipation of a patent of Messrs. Ayrton and Perry in 1882, as alleged. A patentee is not bound in a combination claim to distinguish between new and old parts in the combination, and he has not done so. But in dealing with the question of novelty, it is very necessary to consider how much is new and how much is old, and I shall address myself at once to this inquiry. The electromotor part of the apparatus it is conceded is no novelty. The idea of using the Foucault currents for producing braking action is clearly not new, nor is the idea, in a general way at least, of applying this braking action to an electricity meter. I think it quite impossible to doubt that it is described in definite terms by Ayrton and Perry (specification page 4, lines 43 and 47), where the revolution of magnets in front of a disc is undistinguishable in principle from the revolution of a disc in front of the magnets. Mr. Moulton laid great stress upon the arrangement of the permanent magnets, so as to secure at once a powerful and a constant electric field. I think it is clear that strength of field is pointed out as essential, in order to dwarf the force of friction in comparison, and it is also clear that an arrangement is indicated by which, when permanent magnets are used, constancy may be obtained as well as strength, namely, by taking care that the pole pieces shall be very large as compared with their distance apart. As to electro-magnets, there is nothing new in the method of making them either strong or constant. It seems to me established that Mr. Hookham did invent a form of permanent magnet with great splayed ends where the continuity was broken, which did effectually secure constancy, and that it was really this which made his invention, where permanent magnets were used, a success. He described the conditions of the successful magnet only in the way to which I have called attention, but he did effectually claim it as described as an element of his combination, and he certainly applied his combination motor in the case of electro-magnets or permanent magnets for the first time practically to the purpose of producing an electrical meter. There is also, as I think, novelty proved in the arrangement by which the residual friction which cannot be got rid of is made a negligible quantity. There is therefore in my opinion abundance of novelty to support the claim for the combination. His Lordship then proceeded to deal with the anticipations. Had it been anticipated by the patent of Ayrton and Perry of 1882? Mr. Hookham I am satisfied knew nothing of their patent, and was an independent inventor. In 1884 there was no real demand for meters. Messrs. Ayrton and Perry made their four energy meters, but I think did not sell any, so there is no case of anticipation by user. The evidence is to a certain extent contradictory as to whether from their specification alone an electrical engineer could have given directions to a properly skilled workman which would have enabled him to make, without further experiment, a working apparatus (which is the proper test of anticipation)—I mean a meter that would work. I think, however, that the weight of the evidence is upon this point entirely in favour of the plaintiffs. Probably the evidence of Prof. Silvanus Thompson is the most important for the defendants upon this point, but it seems to me, after carefully re-reading all he has said about it, as it did when I heard him, that he is by no means confident that it could have been done. Handford's patent of 1883 is also said to be an anticipation. I am not quite sure that I understand why Handford adopted the cup armature motor, and put his brake on the same spindle with the armature. But he depended for his brake upon vanes which were to revolve in fluid, and which, except at low speeds, would give a resistance varying more nearly as the square of the force than directly with it. This is clear upon the evidence. Handford's was not, in

my opinion, a practical meter of any sort, and it appears to me to be, from any point of view, a very long way off Mr. Hookham's. I am of opinion that the descriptions and drawings give ample information to enable a workman to construct an apparatus of that type, and no satisfactory evidence has been offered to rebut the evidence for the plaintiff that a skilled workman would easily adapt the arrangements to another type. There remains the very important question of infringement of the claim now under consideration. It follows almost as a matter of course, from the view I take as to the sufficiency of the specification as applied to the cup armature, that with all the improvements and apparent difference introduced into the defendants' apparatus, that I must think it an infringement, unless there be something to qualify the real similarity (despite the different look) which I have pointed out. In my opinion there is not. It is true that the plaintiff's, as figured, has a commutator as a necessary part of the motor, and that defendants' apparatus has none; but the cup armature necessarily involved the absence of a commutator. But it is said the pole pieces are different in two arrangements. The proportions given in lines 20 to 26, on page 5 of the specification between the two ratios there specified, are considerably departed from in the defendants' apparatus, and there is a great difference in appearance. The proportions given, however, are clearly not of the essence of the specification. They are introduced by "preferably." I assume that the patentee has satisfied himself that this was the best proportion between the two ratios when obtainable, as it is with the disc armature. But the only thing that is insisted upon as essential is that the pole pieces should have their surface very large compared with their distance apart. The confined space into which the cup armature of the interior pole piece or pole pieces must be contracted prevents their being of a size or a shape anything like the splayed pole pieces shown in the drawings. The cup armature must be kept small, in order to keep down weight and friction. Relatively to the cup, the total area of the pole pieces, as shown in exhibit G.H.^{4}, is very large, and in the aggregate they constitute a large surface. It must have been obvious to any intelligent reader of the specification that when the invention was applied to a cup armature, the size of the pole pieces must be diminished, and must become more or less of a compromise. Mr. Swinburne says they are smaller in section than those shown in the drawings, but not so small as they look; and he adds that though the proportion between the two ratios did not come in the defendants' meter within what is given as the preferential proportion, "they are somewhat near it." It seems to me that the differences are apparent and not real, and that the arrangement of pole pieces in "G.H.^{4}" (which is only the portion now under discussion of the defendants' apparatus) is in truth that described in the words and drawings in Hookham's specification, with nothing more than the inevitable modifications necessary when the cup armature is used. If the defendants had collected together into one segument the area of the three pole pieces, they would have one pole piece occupying about one-third of the circle. They would have had a worse break, but one in which the pole piece would have looked more like that of G H^1—and yet would have had no more pole piece area than that given by the present arrangement. I have, therefore, come to the conclusion that the plaintiffs' witnesses are right in saying that there is a substantial identity, notwithstanding that which looks like dissimilarity in the apparatus of the specification and that of the defendants; in other words, that the case of infringement is made out. I proceed to the case of the alleged infringement of the sixth claim. Here I entertain a very clear opinion that notwithstanding an appearance of obvious similarity, there is no real identity, and that no infringement has been committed. The sixth claim is for "making grooves in the pole pieces of the magnet of an electricity meter for the purpose of increasing the action of the brake as described and illustrated, &c." The defendants' so-called grooves are in periphery, of what would otherwise be a solid cylindrical pole piece. But a solid cylindrical pole piece never could be used for the purpose of a brake. It would defeat its own end, as the Foucault currents which give the braking power depend upon having some part or parts of the solid cylinder cut away. Mr. Hookham, therefore, must have contemplated the use, with that of a cup armature, of a non-continuous pole piece—which is necessary to create braking power at all—and what he claims is such grooves as would *increase* the power of the brake. It is not a breach of this claim to create a brake by means of a non-continuous pole piece, though it would be when you had got it to put grooves into it to increase its power. You might make a very bad instrument with small braking power by throwing the pole pieces of "GH^4" into one sector. You surely might duplicate that sector in order to get more braking power, or triplicate it, in which case you would be obliged to reduce the size of each sector, or you would get back to continuity of substance, or something very like it. When you triplicated the sector you would get just the arrangement which the defendants have, except that for what I am satisfied are merely structural reasons they have made their triplicate pole pieces with parallel sides instead of giving them the strict form of sector of circles. Not one of these gaps *increases* any Foucault action belonging to anyone of the separate and intermediate pole pieces. They are necessary in order to enable the intermediate magnetised metal to act as a brake at all; and this is equally true of the so-called grooving both inside and outside of the armature. Grooves in the separate pole pieces of "G H^4" would have been infringements. The gaps between the pole piece, however much they may give to a triple pole piece the appearance of being grooved, are, I am quite satisfied, no infringement of the sixth claim. Objections have been made to 2, 3, 5, and 8, on the score either of disconformity or want of novelty. The objection to claim 3 is practically answered by what I have said in discussing the first claim. The evidence is conflicting, but I am of opinion that although Prof. Ayrton and Perry's specification points out very nearly all the theory of the matter, it stopped there; that there was no prior publication of any practical way of procuring a constant field of permanent magnets, and that the patentee is entitled, although they are not mentioned in the provisional specification, to claim their use in electricity meters, as a fair extension of the provisional specification. As to the fifth claim, I understand the objection to be that it is unlimited in its terms, and might apply to all uses to which such a commutator could be put. It is, in my opinion, a very copious objection. It is plain it is intended to apply only to the arrangement used in connection with electricity meters or with dynamo-electric generators and motors. The eighth claim relates to a very small invention, but one not at all wanting in ingenuity, but in diminishing friction and subserving the general puposes of the invention, confined, like claim 5, to use in electricity meters and dynamo-electric generators and motors, because the whole subject matter of the specfication is confined to them. It is not to be supposed for a moment that the patentee meant in these two claims, and any other not specifically limited to electricity meters to go into the whole field of possible mechanical use for such inventions, to diminish friction in any electricity meter, especially as in this. One idea upon which stress is laid in the specification is to make the electromotive action, and, of course, the braking action also very large in comparison with friction, so that friction may be, in the phrase of the patentee, "negligible." The reason for this is that the motor action and the braking action are both proportional to the velocity of the armature. Friction is not so, but varies roughly as the square of the velocity. If, therefore, friction has to be taken into account, the problem to be solved is greatly complicated. Of course, under these circumstances, friction should, in the first place, be made as small as possible, and this eighth claim relates to a mechanical contrivance, clearly new, which does something towards diminishing friction, and is therefore useful. I have thus disposed of everything except the objection to the second claim, which is that there is no invention at all in it. As usual, much of the difficulty disappears if the claim be carefully construed. It says: "Secondly, in electric-meters, the obtaining of a constant field, either for the brake or armature, or both, by the use of electro-magnets of such construction and dimensions that they became saturated while in use in the circuits, of the kind for which they are designed, substantially as described." It does not seem to me to be a happy specimen of drafting, but its meaning is clear enough. The phrase, "as described," cannot apply to the mode of construction, winding, &c., of the magnets, because no description is given. It is therefore the method of obtaining the constant field to which the words "as described" refer, and I read the claim as equivalent to "the obtaining in electricity meters a constant field by the use of saturated electro-magnets." This constancy of field is a very important matter in Mr. Hookham's apparatus, because his is a current meter, and only indirectly and in certain circumstances an energy meter. In electric lighting, to take an instance, the customer pays for energy; Mr. Hookham measures current only. If the pressure is constant, as it is practically in the supply for lighting, current is proportional to energy, and energy is measured when the current is measured. Messrs. Ayrton and Perry, whose specification contains the only serious approach to anticipation, propose to measure energy whether the pressure be constant or varying. There is, in this instance, a good deal of ingenuity in the novel application of an old process. It has been urged upon me that the decision I have arrived at will involve upon Prof. Perry, one of the patentees of 1882, great hardship, inasmuch as the defendants are the licensees, working under a patent of 1890, and that it is a strange thing that one of the two men who laid down the correct theory and indicated the lines upon which to work, should be then "hoist with his own petard." I am very truly sorry if my decision does involve hardship, but I cannot help the conclusions I have arrrived at. They seem to me, after the most serious consideration, to be the right ones, after which there is no more to be said. But it is well known law—no intelligent patentee can be ignorant of it—that in order to give right to a monopoly, the patentee must not merely set a problem and render it not very difficult to solve, but must condescend to practical details, so that at the expiration of the patent the rest of the world may be able, without further experiment, to make the patented article. This condition, I think, Messrs. Ayrton and Perry did not fulfil, and if so they cannot complain that another should travel by the road they have discovered up to the door which they did not unlock, and having found the key himself, should unlock the door, go in, and shut them out. My judgment, for the reasons given, must be for the plaintiffs, with the injunction and account prayed for and delivering up of infringing articles. I certify that the validity of the Letters Patent No. 4,225 of 1887 granted to Geo. Hookham came in question, and that the particulars of the breaches, excepting those relating to the grooving of pole pieces has been proved. The inquiry has been materially lengthened by the charge of infringement of the sixth claim, and I think my order as to costs ought to be that the costs be taxed as if the plaintiffs had succeeded in all the matters in dispute and the allocatur be given for three-fourths of the sum so ascertained. The costs to be taxed on the higher scale.

Mr. Jenkins said the defendants would like to consider their position, and asked for stay of execution for a fortnight on the usual terms.

The application was granted, the costs to be paid on the usual undertaking.

New & Mayne *v.* Hooley.

In the Official Referees' Courts branch of the Chancery Division of the High Court of Justice on Monday, April 12th, before Mr. E. Ridley, Q.C., the case of New & Mayne Company *v.* Hooley was set down for hearing. Mr. F. Dodd appeared for the plaintiffs, and Mr. Stanger, Q.C., with Mr. Crumpton (for Mr. Willes Chitty), for the

defendant, Mr. Ernest Terah Hooley. Plaintiffs are electrical engineers, and the action was on an account for an installation of the electric light at defendant's residence, Risley Hall, near Nottingham.

Mr. Dodd, at the outset, represented that he was in a rather serious difficulty. Defendant was ordered to deliver particulars within seven days from February 12th, but they were not delivered until March 23rd, and further particulars were not forthcoming until the 2nd inst. It was true that plaintiffs' experts had made an inspection, but only extending over an hour and a half, but it was perfectly clear that was not sufficient. The claim was for £2,442, and the inspection involved going over the house, the church, the outbuildings, and an engine house built by defendant himself, containing a dynamo and boiler. Counsel was practically helpless in the matter; he could not go on with the evidence which he had before him. It was not a contract job, and there were no specifications; it was simply one of time and labour. Since April 7th, when the Official Referee gave the order for witnesses to inspect, everything possible had been done, but plaintiffs knew they were to be met on the part of the defendant by expert witnesses, who had had ample time to inspect the work.

Mr. Stanger did not oppose the application for an adjournment, but asked that plaintiffs should pay costs.

The Official Referee intimated that he should grant a postponement, and reserve the matter of costs.

At this stage, Mr. Hooley entered the Court, and had a brief consultation with his solicitor. Then there was a short conference between counsel, and

Mr. Stanger announced that the record would be withdrawn; plaintiffs had agreed to accept £2,000 in full satisfaction of the claim, no costs on either side, and no further claim to be made by the plaintiffs.

Cant *v.* Fernhead.

At the Clerkenwell County Court, before Judge Meadows-White, Benjamin Charles Cross Cant, Crown Works, Amhurst Road, Hackney, engineer, sued Alexander Fernhead, of 354, Caledonian Road, to recover £20, balance of an account for the installation of the electric light at the Alliance Hotel, West Hampstead. The plaintiff's case was that the defendant, having obtained the contract to renovate the hotel referred to, employed him to furnish the electric light. During the progress of the work defendant had paid him £30, but plaintiff refused to proceed with the work until he was paid the balance of his account. Mr. Fernhead's defence was that the plaintiff was not entitled to recover, as the work had been badly done. His cross-examination of the plaintiff was intended to show that the latter knew nothing about electric lighting, and only electric bells, which he had been in the habit of supplying. The Judge, however, found for the plaintiff for the full amount claimed.

BUSINESS NOTICES, &c.

Electrical Wares Exported.

Week Ending April 13th, 1896	£	s.
Antwerp. Elec. fuses...	218	0
Auckland	35	0
Bangkok	10	0
Bombay	81	0
„ Teleg. mat. ...	324	0
Brussels...	268	0
Calcutta...	937	0
Cape Town	50	0
Colombo	42	0
East London	716	0
Kobe	324	0
Madras	10	0
Malta	250	0
Melbourne	28	0
Montreal	18	0
Newcastle	84	0
Otago	62	0
Oporto	50	0
Passages... ...	23,200	0
Port Elizabeth	66	0
Rangoon	12	0
Rotterdam	132	0
Shanghai	518	0
Sydney	248	0
Total	£27,683	0

Week Ending April 13th, 1897.	£	s.
Alexandria	140	0
„ Teleph. mat.	90	0
Amsterdam	100	0
Antwerp	17	0
Auckland	231	0
Bombay...	134	0
Brisbane. Teleg. mat.	738	0
Buenos Ayres	77	0
Cairns. Teleg. mat. ...	26	0
Calcutta	50	0
Cape Town	538	0
„ Teleg. mat.	3,536	0
Colombo	12	0
Delagoa Bay. Teleg. mat.	5,837	0
Durban	261	0
East London	174	0
Flushing	92	0
Gottenburg	19	0
Hamburg. Teleg. mat.	158	0
Madeira...	25	0
Madras	45	0
Malta.	90	0
Marseilles. Elec. Launch	225	0
Melbourne	99	0
Ostend	76	0
Paris	380	0
Port Elizabeth	558	0
„ Teleg. mat.	155	0
Quilimane. Teleg. mat.	482	0
Reval	113	0
Rockhampton	350	0
Santos	202	0
Shanghai	189	0
„ Teleg. mat. ...	820	0
Singapore	54	0
Stockholm. Teleg. mat.	55	0
Suez Teleg. mat. ...	190	0
Vigo. Teleg. mat. ...	26	0
Wellington	48	0
Yokohama	200	0
Total	£16,612	0

Foreign Goods Transhipped.

	£	s.
Wellington. Telephones	675	0
Total	£675	0

	£	s.
Delagoa Bay. Teleg. mat.	811	0
New York	18	0
Total	£829	0

Bankruptcy Proceedings.—At the London Bankruptcy Court last Tuesday the first meeting of creditors was held, under the failure of George Frederick Lee, lately trading at 111, Sydney Street, Chelsea, as Lee & Hancock, electrical engineers. The partnership was initiated in May, 1895, with a joint capital of £30. Mr. Hancock withdrew in September following, and the debtor continued the business until the stock and effects were sold under a distraint by the landlord last January. To a loss of £20 by such distraint, combined with bad debts and law costs, the failure is attributed. The debts are returned at £191 5s. 3d., and the assets at £19 11s. 9d. In the absence of any offer, the case was left with the Official Receiver to be wound up in bankruptcy.

Change of Address.—Messrs. Fairfax & Wetter, patent and trade mark agents and consulting engineers, have removed to 37 and 39, Essex Street, Strand, London.

Dissolution of Partnership.—Messrs. H. D. Parmiter and M. H. Barber, carrying on business as Donnison Parmiter and Barber, as electrical engineers, at 10, Corporation Street, Manchester, have dissolved partnership by mutual consent. M. H. Barber will continue the business, and attend to debts.

Edison & Swan United.—We understand that the Edison & Swan Company have received the contract for the supply of all high voltage lamps required by the Blackpool Corporation. The order for switchboard for the Bray Township Commissioners, and also for the Asylum Board Hospital at Tottenham, have also been placed with this company.

Electric Cooking Apparatus.—Messrs. Crompton and Co., Limited, announce that, as they are removing their electric heating and cooking works from London to Chelmsford, they are offering an additional 15 per cent. beyond the usual trade terms to dispose of the London stock of kettles, saucepans, warmers, radiators and other apparatus to avoid their removal.

Jubilee Illuminations.—We have this week received several lists, which give evidence of the activity among electrical firms in electrical illumination work. The General Electric Company have issued a sheet showing a specimen of electrical illuminations, also giving particulars of semi-transparent waterproof balloons for enclosing incandescent lamps. The Edison and Swan Company have brought out a very nicely got up pamphlet describing, illustrating and priceing, "Ediswan" illuminated signs and devices of various kinds. Mr. Berthold Groote, of Nuremberg, sends a list giving sketches and details of the "Jubilee" electric illumination lamp, which is connected to the temporary electric wires (when placed on each side of a vertical board) by means of two springs, having the appearance of a clip. This would seem a quick and easy means of fitting up lamps for any special occasion.

The Fyfe-Main Electric Lighting and Construction Company, of Electric Avenue, Brixton, send us a few particulars of electric illumination work of which they make a speciality, also a photographic reproduction of Electric Avenue as it appeared last Christmas when decorated and illuminated for the festive season.

Kerbey Bowen & Co., Limited.—In this case Mr. Justice Romer, on Friday, the 9th inst, in the Chancery Division of the High Court, at the suit of debenture holders, appointed a receiver and manager of the company, limiting the manager's appointment to three months. Counsel, in support of the application (which was assented to by the company), stated that the business was that of electrical engineers and manufacturers of electrical launches. The company was incorporated in 1894 with a capital of £20,000, and in 1896 issued two sets of debentures, which were a charge on its undertaking. The business had been carried on at a great loss, and the company was now insolvent.

Meeting of Creditors.—At a meeting of creditors in the Wigston Electrical and Engineering Company, Limited, held on 9th inst., the liquidator (Mr. Wykes) submitted an account showing the realisation of the estate up to the present. A first dividend of 6s. 8d. in the £ was declared.

South London Electric Supply Corporation.—We have been notified that the office of this company will in future be at 28, Victoria Street, Westminster, and that the directors have appointed Mr. Sidney H. Webster, secretary of the company.

Stealing Electric Current.—At Hastings Police Court last week, Frederick Valentine Kirkham was summoned for having fraudulently used electric current, the property of the Hastings Electric Light Company. An arc light fitter in the employ of the company, said that about noon on March 22nd he went to the defendant's premises for the purpose of fixing a clock motor. The private entrance was open, and witness went through into the coal cellar. In the passage near the cellar he found a twin flexible wire running along the wall from the kitchen to the cut-out. On the wire in the passage there was an incandescent lampholder, and then the wire continued over the kitchen door. Going back to the cut-out he found a portion was loose. He took off the lid and found the wire attached. He ascertained that current was passing through the wire. The effect was that the current passed direct to the lamp without being registered by the meter. Defendant came in but did not say anything. The same afternoon witness went to the premises with another man. He then found that the lampholder and wire had been removed. The defendant pleaded guilty, and was fined £3 and costs.

The Municipal Year Book.—The Municipal Year Book of the United Kingdom for 1897, which is compiled by Mr. Robert Donald, the editor of *London*, from the offices of which paper the book is published has been issued. There is a good deal of very useful information regarding municipal authorities, their officials, and the schemes in hand. The two sections of chief interest to our readers are electric lighting and tramways. The electric lighting accounts to December, 1896, are given wherever they have been available, and in other cases they are only made up to March last year. This year book should be of service to electrical firms doing business with municipal authorities. The price is 2s.

The Universal Engine and Mordey Alternators.—The Huddersfield Corporation have placed their extension order for plant for next winter with the Brush Electrical Engineering Company. The extension, we understand, will consist of a steam alternator of 300 kw. capacity, and the Huddersfield Committee, after visiting several manufacturers works in the North, have decided to adopt the Brush Company's Universal steam engine and Mordey alternator. It will be remembered that the Huddersfield station commenced with the Brush Company's plant; in 1895 a Ferranti extension plant was installed, and the extension now ordered is again from the Brush Company. We understand that the combination of Universal steam engine and Mordey alternator is being introduced into the following, amongst numerous other central stations for the coming winter, namely:—Wandsworth, Windermere, Hastings, Huddersfield, Sheffield. A Universal engine is also on order for the Cheltenham station.

Veritys, Limited.—Messrs. Veritys, Limited, at Easter are making another large departure in connection with their wholesale electrical business by the opening of large premises in the rear of their present offices in King Street, Covent Garden, for the supply of cables, wires, electrical accessories, motors, and machinery generally of all kinds. A special agency has been arranged by Messrs. Veritys for the sale and stocking of Messrs. W. T. Glover & Co.'s cables and wires in London, and also with Messrs. Mavor & Coulson for their C.C. system of concentric wiring. These, together with flexible cords and every other kind of wireman's sundries, will constitute one of the new departments. Another new feature is the machinery department, including the supply of electrical motors, and it may be remembered that it was mentioned a few weeks ago that Messrs. Veritys had obtained a license for manufacturing the Lundell motor, which are so well known in the United States. We hear that the demand for this type of motor is on the increase in this country for domestic and other purposes. In this department are various useful appliances and several novelties in the way of stage arc lamps, while there are also included various resistances. Veritys, Limited, have recently acquired a license for the manufacture of Lyons liquid resistance, while they also have the exclusive agency in this country for the Ward Leonard Carpenter enamel rheostat and iron clad resistances largely used in the United States. In their electrical accessories department Messrs. Veritys have just issued a very substantial new catalogue containing illustrations of all kinds of electrical accessories as manufactured by them. Switchboards, switches, cut-outs, fuses, ceiling roses, wall plugs, and lamp holders are the principal headings of the book, which is got up and printed in most excellent style. A good enamelled paper helps to show off the finely-cut blocks to advantage. We understand that Messrs. Veritys' chief point is that every article contained within its pages is of their manufacture. The book is very complete, and systematically arranged. Many of the articles are illustrated by means of diagrams as well as general views. In the main switchboard section, every switch is accompanied by a diagram, which not only serves to show the manner in which it should be connected, but also gives its outside dimensions for each capacity. A number of useful original tables have been included. These are, we understand, compiled from the very highest authorities. On page 20 details have been included of cable thimbles never before tabulated but of great importance. The subject of safety fuses has been entered into very thoroughly.

ELECTRIC LIGHTING NOTES.

Aberdeen.—The Gas and Electric Lighting Committee last week recommended the adoption of a scheme for increasing the capacity of the electric mains by 22,000 lamps, at an expenditure of £3,754. The report was approved by the Town Council. A new system of charging and the abolition of meter rents come into force in July.

Bangkok.—The Siamese Government has granted to an American citizen an exclusive concession for the electric lighting of Bangkok.

Belfast.—The Electric Committee has prepared a report to the Council relative to the proposed new installation, and given the engineer instructions to have matters advanced as quickly as possible, so as to supply current from the first sub-section of the new station next winter.

Birkenhead.—The Town Council last week decided to apply to the Local Government Board for sanction to a £20,000 loan for electric lighting purposes, as follows:—For costs, charges, and expenses incurred in excess of the amount of £20,000 originally authorised to be borrowed and to meet other expenses, £5,000; for providing and laying feeding mains, distributing mains, street boxes, and other main connections in the districts of Oxton and Claughton, £10,000; and for providing additional generating plant, £5,000. Alderman Bloor explained that the originally authorised expenditure of £20,000 had been already exceeded by £3,500, which was explained by the engineer as due to the extended area of streets served.

Blackpool.—An alarming outbreak of fire occurred at the Blackpool Corporation Electricity Works early last Friday morning. For the last two months or more, says a provincial daily, over 200 men have been engaged upon the work of laying new electric cables throughout the town, and in order to get the job finished before Easter, night and day shifts have been employed. The cables, it should be explained, are laid in a kind of resinous compound to preserve them against the action of saline matters in the soil. This mixture, which is exceedingly combustible, was being prepared in a cauldron adjoining the electricity works, when it is supposed to have boiled over. Flames immediately shot up to a great height, and set fire to the roof of the engine house, in which is plant to the value of £50,000. Fanned by the wind, the fire spread to an adjacent stack of barrels containing Stockholm tar, and for some time the works were in imminent danger of destruction. The fire brigade, who were quickly on the spot, succeeded, however, in preventing much damage being done to the main building. The loss will fortunately not be very great, but the fire will have the effect of delaying further progress with the laying of the street cables until after Easter.

Brighton.—The Lighting Committee have decided that all electric streets which were formerly fitted with 4-feet gas burners, shall now be fitted with two electric lamps of 8 C.P. each, and that where 5-feet gas burners were in use, two 10 C.P. electric lamps shall be fitted. The effect of this will be to double the lighting power in each case.

Bristol.—At the last meeting of the Electrical Committee, tenders for the condensing plant required for the new electrical works were received as follows:—

	£
C. S. Mallett & Co.	7,588
J. Fraser & Son	6,969
H. Watson & Son	6,412
W. H. Allen, Sons & Co.	5,750
Cole, Marchant & Morley	5,412
J. Hargreaves & Co.	4,500
D. S. Stewart & Co. (part)	1,028

The committee adjourned the consideration of the matter until the next meeting, without accepting either of the tenders.

The Bristol Chamber of Commerce in their annual report to be presented at the meeting to be held later in the month mentions with satisfaction the fact that "the electric lighting under the control of the Electricity Department of the Corporation continues to make rapid progress both as regards engineering development and financial results. On March 1st, 1896, there was connected to the mains 485 customers with 27,707 lamps; on March 1st, 1897, there were connected 614 customers with 38,303 lamps, showing an increase of 38 per cent. in the demand by private customers." The report says, "Nine new sub-stations have been formed, bringing up the total number of sub-stations to 31, showing an increase of 20 on the number originally in use in 1894." Mr. Faraday Proctor, the City Electrical Engineer, has designed very considerable extensions to the works at Temple Back, entailing an addition to the capital expenditure of £75,000; and contracts have already been entered into for most of the work, which includes the extension of the buildings, five additional Lancashire boilers, two steam alternators of 800 H.P. each, 1 steam dynamo of 100 H.P., and all the auxiliary plant, such as mechanical stokers, economisers, condensers (with a capacity of 72,000 lbs. of steam per hour), evaporators, and sundry electric motors and pumps. The principal deviation from past practice will be in the driving of all the auxiliary plant by electricity instead of by steam. The extensions at the Generating Station will all be carried out by contract, but all extensions of the distributing system, including the equipment of new sub-stations, are carried out by the staff of the Electricity Department, under the supervision of Mr. Faraday Proctor.

Derby.—When the Council reconsidered the report of the Electric Lighting Committee on 7th inst., a motion to appoint Messrs. Bramwell and Harris as consulting electrical engineers, was again rejected, the voting being 29 to 18; £20,000 was voted for extending the electric light plant. It is proposed to spend £10,250 in machinery, £8,650 in mains and services, £450 in buildings, and £650 in accumulators. At the end of 1896 there were 77 arc lamps and 16,105 private lamps being supplied. This year another 1,000 incandescents have been added, and before long the station will reach the limit of its output, hence the necessity for the extensions. The Technical College is to be wired at a cost of £301.

Edinburgh.—The Town Council has authorised the Treasurer of Police to carry the net surplus on the electric lighting account at the close of the current year to the credit of the burgh assessments.

Hastings.—The Town Council, sitting "in committee of the whole house," has decided to purchase the undertaking of the Hastings Electric Light Company. The property acquired includes a large building at the junction of South Terrace and Earl Street, fitted with the latest improved machinery, and mains through most of the principal streets.

It is understood that the company's offer was for £58,000, and the whole matter will come up at the next monthly meeting of the Town Council. The Council are erecting works at Queen's Road, and with the Electric Light Company's works, it will be possible to make street lighting in the borough by electricity pretty general.

Eccles.—By 12 votes to 9 the Town Council has adopted the following recommendation of the Town Hall and Electric Lighting Committee:—"That, assuming that the Council can be satisfied by the report of a deputation that incandescent street lighting at Brighton is successful, and that it would be likely to be successful if adopted in Eccles, the scheme now presented by Mr. Clirehugh for lighting the main thoroughfare from Gilda Brook to New Lane, Winton, by the incandescent system of electricity, together with 4½ miles of mains for private consumers, be adopted for the present, such scheme being capable by subsequent extensions of lighting street lamps and supplying consumers throughout the borough, if the Council should hereafter so determine."

Hemel Hempsted.—The electric lighting of the Bury Mills, to which we referred last week, was carried out by the Watford Engineering Works.

Hospital Lighting.—A letter from the Local Government Board was read at a meeting of the Metropolitan Asylums Board last Saturday, sanctioning the managers' proposal to enter into a contract with one of eight selected firms for the supply and fixing at the Grove Hospital of the boilers required in connection with the heating and electric lighting works at that Hospital, without, in the first instance, advertising for tenders. The names of the firms were, however, not disclosed.

Hull.—The Electric Lighting Committee has approved of the plans for the buildings in Sculcoates Lane in connection with the electric lighting extensions, the details being left for the electrical engineer to arrange.

Leeds.—The City Council have decided, by way of experiment, to light Wellington Street, Boar Lane and Briggate by electricity, the lamps being fixed to the tramway poles. For 10-ampere lamps the capital cost would be £510, and the annual expenditure £574; for 6·8 ampere lamps the capital cost would be £465, and the annual expenditure £422.

Lewisham.—A memorial has been presented by the inhabitants of Blackheath and neighbourhood asking the Lewisham Board of Works to sanction the Blackheath and Greenwich electric lighting provisional order; but the board who dealt with the matter in committee have decided to continue their opposition unless the company agree to limit their operations to the Blackheath district, or agree to terms which permit of the board being able to purchase the undertaking after seven years from the date of the order, and that special terms should be given for the electric lighting of the public lamps in the district.

Liverpool.—The St. John's Market will shortly be lighted by electricity, the initial cost being about £900. The Police Courts and offices are also to be lighted.

Motherwell.—The provisional order granted to the Commissioners in July, 1895, being in danger of lapsing, a full report on the matter will be brought before the next meeting by Baillie Findlay, who will move that a scheme be proceeded with.

Newport.—A proposal to apply for sanction to borrow £31,000, required for electric lighting extension, is before the Council.

Plymouth.—Among the recommendations of the Electric Lighting Sub-Committee submitted to the meeting of the Plymouth County Council on Monday was the proposal that the tender of Messrs. S. Z. de Ferranti, Limited, for steam alternators and dynamos shall be accepted. Messrs. Ferranti's tender was the highest of the four tenders received, and the difference between their total (£13,401 14s.) and the lowest tender is nearly £1,700.

Salford.—The Council has decided to appoint a separate committee to manage the affairs of the electric light department.

Sheffield.—The Parliamentary Committee are of opinion "that it is advisable that the City Council should put in force the powers reserved to the Corporation," and they "recommend them forthwith to give notice for the purchase of the Electric Light Company's undertaking."

South Shields.—The Corporation want a mains superintendent to act as temporary assistant to the borough electrical engineer in connection with the extension of the mains, arc lamps, &c. See our "Official Notices" for particulars.

Swindon.—Mr. J. G. W. Aldridge is being consulted by the Town Council in respect of electric lighting, and at the first meeting of the Council in May his terms thereon will be discussed.

Torquay.—The Electric Light Committee has considered the proposals for the free wiring of houses received from Messrs. Pearson & Co., Messrs. Massingham & Mann, and Messrs. Williams Bros. & Co. The Council has adopted the scheme of Messrs. Massingham & Mann, without that firm being considered the sole contractors.

Windsor.—The Windsor Electrical Installation Company, Limited, who have only been supplying current to the public during the last three months, have already found it necessary to enlarge their staff, and Mr. W. T. Le Feuvre, who for some years has been in the electric department of the General Post Office, London, has been appointed assistant engineer to Mr. A. E. Farrow.

Worcester.—The report of Mr. Ruthven Murray, the city electrical engineer, regarding the past year's work, was adopted by the Council on 6th inst. We dealt with the report somewhat fully in our April 2nd issue. £9,000 is to be spent upon additional plant at the Powick station, and an alteration is to be made in the system of charging consumers.

ELECTRIC TRACTION AND MOTIVE POWER NOTES.

Birmingham.—The recommendation of the Continental deputation, to which we referred last week, has given rise to a good deal of discussion locally. A deputation, consisting of Mr. Ross, Mr. R. H. Milward (solicitor), and Mr. Cunningham, C.E. (general manager of the Montreal Street Tramways Company), representing the City Tramways Company, had an interview with the Public Works Committee on 6th inst., on the subject of the sub-committee's report upon systems of traction. The meeting occupied 2½ hours in the morning, and was then adjourned until after the meeting of the City Council. It was then ascertained that the representatives of the company had been asked to submit an alternative scheme, but that they had declined to do this, stating that if the committee advised the Council to insist upon the conduit system the company would have no alternative but to continue the present objectionable steam traction. They urged that if the Council wished for a luxury in the way of the conduit system they must allow the company special facilities for providing it. In the evening the deputation again met the committee, and they were in further consulation for two hours, the town clerk being also present. At the close of the sitting Mr. Milward informed a local pressmen that no further progress had been made, and that the matter had been adjourned. Alderman White, the chairman of the committee, stated that the whole question had been deferred for a month, until Mr. Pearson, the engineer to the company, who was now in America, arrived in England.

Bristol.—The Surveyor of the Stapleton District Council has received a communication from the Tramway Company to the effect that the electric trams would run as far as the Full Moon, Fishponds, in August.

Electric Clocks.—We learn from a daily exchange that the Dundee Town Council have decided not to open tenders for electrically controlling the public clocks in the city, but to invite tenders from local tradesmen to regulate the clocks on the old system for six months.

Electric Organ Blowing.—Electric motors are to be used for driving the blowing apparatus of an improved organ, which is about to be placed in Lincoln Cathedral.

Electric Launches.—The Thames Valley Launch Company, Limited, of Riverside Works, Weybridge, are delivering a 45 feet electric launch to the Corporation of Southport to run on the artificial lake at Southport, and also one of 30 feet in length, a cabin boat, and a small open electric boat to the Chester Boat Company to run on the Dee. They have delivered since last season, six launches and one large down river sailing craft of entirely new design, among the launches being one for the War Department.

Glasgow.—The Glasgow Corporation Tramways Committee again last week considered the question of mechanical haulage. Mr. Walter Paton, convener, dwelt at length upon the reports of Mr. John Young as to the various systems of mechanical traction he had witnessed in operation while on an official visit to America. The committee decided by 16 votes to 4 to recommend the Corporation to proceed, by way of experiment, with the equipment of the Springburn route on the trolley or overhead system of electric traction. The distance of the route from Mitchell Street to Springburn is about three miles. They also agreed to invite the co-operation of the Watching and Lighting Committee in order that the street lamps along the route might be lighted with the same power as will be employed in working the tramway motors.

Isle of Thanet.—Last week a meeting of the Ramsgate Town Council was held to consider the scheme for the proposed electric railway, in accordance with the memorial recently presented by a deputation. Alderman Green, Chairman of the General Purposes Committee, moved "That the resolution passed by the Council on February 4th last, adopting the report of the General Purposes and Parliamentary Committee of January 26th ult., relating to the light railway proposed to be constructed in the Isle of Thanet be rescinded, and that the whole subject be reconsidered at this meeting." Alderman Wood seconded, and the resolution was carried. Councillor Barnett urged that the town should be polled to ascertain the opinion of the burgesses. Councillor Poole moved that the Town Clerk be instructed to oppose that portion of the scheme relating to the front part of the town, from West Cliff to Bellevue Road. A lengthy discussion ensued. Councillor Barnett urged that the matter was too important to take a vote upon that night, and, as an amendment, he proposed the matter be adjourned for a fortnight to enable the Town Clerk to obtain the opinions of those who resided where the electric tramway system was in vogue. The amendment was carried by nine votes to six.

Ipswich.—According to an announcement in connection with the Ipswich Tramways Company, it is rumoured as being within the bounds of possibility that the cars may in future be worked by a new motive power. Towards the end of the present month, says a Norwich paper, an extraordinary general meeting of the shareholders is to be held for the purpose of considering, and, if thought fit, accepting an offer from the British Gas Traction Company for the undertaking of the Ipswich Tramway Company, and of approving an agreement for carrying out that object.

Speed of Electric Cars.—Major Marindin's report of the recent inquiry at Dublin has led to a declaration on the part of the Board of Trade that the speed on the Dublin Southern District tramways may be 14 miles an hour, maximum. The local authorities will have power to reduce the speed by a bye-law.

Statistics of Electric Railways in Europe.—The following tables, taken from the *Elek. Zeit.*, are said to show the extension of electric railways in the different countries of Europe on January 1st, 1896, and January 1st, 1897. They show at a glance the progress that has been made during 1897, though the figures in some cases appear to be somewhat understated. The second table shows the various systems of working in use.

	Total length of the lines in miles.		Total output of the power stations in kilowatts.		Total number of motor cars.	
	1897.	1896.	1897.	1896.	1897.	1896.
Germany	400	290	18,963	7,194	1,631	857
France	174	82	8,736	4,490	482	225
Great Britain	78	67·5	5,156	4,683	200	168
Italy	72	24·5	5,970	1,890	289	84
Austria Hungary	52	44	2,389	1,949	194	157
Switzerland	49	29	2,622	1,559	129	86
Spain	29	18	600	600	40	26
Belgium	21	15·5	1,220	1,120	73	48
Russia	9	6·4	870	540	48	32
Servia	6·4	6·4	200	200	11	11
Sweden and Norway	4·6	4·6	225	225	15	15
Bosnia	3·5	3·5	75	75	6	6
Roumania	3·4	3·4	140	140	15	15
Holland	2·0	2·0	320	320	14	14
Portugal	1·8	1·7	110	110	3	3

Systems.

	Lines with overhead conductors.		Lines with underground conductors.		Lines with middle rail.		Lines with Accumulators.		Total.	
	1897.	1896.	1897.	1896.	1897.	1896.	1897.	1896.	1897.	1896.
Germany	45	35	2		..	..	4	..	51	36
France	19	11	1	..	1	1	5	4	26	16
Great Britain	11	8	1	1	7	8	1	1	20	18
Italy	9	7	..	..	..	..	..	..	9	7
Austria Hungary	7	6	2	1	..	..	1	2	10	9
Switzerland	17	12	..	..	..	..	..	..	17	12
Spain	3	2	..	..	..	..	..	..	3	2
Belgium	4	3	1	..	..	..	..	..	5	3
Russia	2	2	1	..	..	..	..	..	3	2
Servia	1	1	..	..	..	..	..	..	1	1
Sweden and Norway	1	1	..	..	..	..	..	..	1	1
Bosnia	1	1	..	..	..	..	..	..	1	1
Roumania	1	1	..	..	..	..	..	..	1	1
Holland	..	..	..	..	..	..	1	1	1	1
Portugal	1	1	..	..	..	..	..	..	1	1

The Tramways Institute.—Before the Tramways Institute, at its Huddersfield meeting last Thursday, papers were read as follows:—"The Huddersfield Corporation Tramways and the Municipalisation of Tramways," by Mr. J. Pegson, M.I.M.E.; the "Walker System of Electric Traction," by Mr. Justin Eck, M.A., M.I.E.E., Chief Engineer and Managing Director of Messrs. Laing, Wharton and Down, who are the English representatives for the Walker system. On Friday the 9th inst. the members of the Institute proceeded to Prescot and inspected the short length of line on the "Simplex" system, Mr. Waller being present to explain the method.

The Underground Railway Schemes.—The Select Committee of the House of Commons presided over by Mr. Woodall last week, gave its decision with respect to the schemes proposed in the City and West End Railway Bill and the Brompton and Piccadilly Circus Railway Bill. Both Bills contain proposals for the construction of underground electric railways—in the one case, from Cannon Street, in the City, to Hammersmith, with frequent stations; and, in the other case, from Piccadilly Circus by way of Piccadilly and Hyde Park Corner, to Brompton Road. The committee, having heard a great deal of evidence both for and against the Bills, now decided that the preamble of the Brompton and Piccadilly Circus Bill was proved, and they rejected the City and West End Bill. They have also heard evidence, says the *Times*, with respect to the deep-level scheme of the Metropolitan District Railway Company between Earl's Court and the Mansion House, but the further consideration of this Bill was adjourned until after Easter.

TELEGRAPH AND TELEPHONE NOTES.

Birmingham Telephones.—The National Telephone Company has, we understand, erected a handsome building in Edmund Street and Newhall Street, Birmingham, which will be ready for occupation in about three weeks. The offices of the provincial superintendent and district manager will be on the first floor, the second being set apart for the exchange rooms. The remainder of the building will be let off.

Exports of Telegraph Wire and Apparatus.—Unusual activity prevailed in the export trade of telegraph wire and apparatus connected therewith during the past month, the value of the total shipments being returned at no less than £139,642 as compared with only £43,710 in the preceding month, and only £21,238 in the corresponding month of last year. As a result of this activity during the past month the returns for the first quarter of the year present a much more satisfactory state of affairs than was the case a month ago, as against a decrease of over £60,000 there is now an increase of over £50,000, the total value of the exports for the past quarter being £245,472, as against £188,302 in the corresponding period of last year, and only £64,202 in the first three months of 1895.

Telegraphic Interruptions and Repairs:—

Cables.	Down.	Repaired
Brest-St. Pierre (Anglo, 1869)	April 6th, 1895 ...	...
West Indies—		
Puerto Plata-Martinique	Dec. 19th, 1895 ...	...
St. Croix-Trinidad ...	Nov. 30th, 1896 ...	...
Jamaica-Colon	Feb. 6th, 1897 ...	...
Amazon Company's cable—		
Parintins-Itacatiara ...	May 5th, 1896 ...	...
Obidos-Parintins ...	Dec. 7th, 1896 ...	...
Emden-Vigo	March 24th, 1897 ...	March 30th, 1897.
Benguela-Mossamedes * ...	April 14th, 1897 ...	...

* This interruption cuts off communication with the Cape *viâ* the West Coast route.

Landlines.		
Trans-Continental line beyond Mazol	March 12th, 1896 ...	...
Carthagena - Barranquilla (Columbia)	July 4th, 1896 ...	...

April 7th.—Katarina-Larissa route impracticable.

April 9th.—Telegrams for Ecuador are subject to censure at Guayaquil.

International Telephonic Communication.—The work of erecting an international telephone line between Budapest and Berlin was commenced on the 1st inst. The line will be about 1,000 kilometres long.

Manchester Telephones.—An influential deputation waited upon the Mayor of Salford (Alderman Richard Mottram) last week, to present a memorial, and ask for the assistance of the Salford Borough Council in the movement to secure a mutual telephone system for Manchester and district. The Mayor, in reply, said he had heard of former companies having been bought up, and if that sort of thing went on it would be a great disadvantage to commercial people in this district. The memorial should receive careful consideration from the Council.

North Borneo Telegraphs.—Reuter's Agency is informed by the Secretary to the British North Borneo Company that telegraphic communication is now established between London and Sandakan.

River Plate Telegraph Company.—The River Plate Telegraph Company, which applied to the Argentine courts for permission to open its offices pending a full investigation into the matter of their compulsory closing by the Argentine Postmaster-General, has been refused permission to do so under any circumstances. The judgment is principally composed, says the *Financial News*, of a lecture to the company on its "impertinence" in daring to hint at an action against the Government. The company's offices will therefore have to remain closed until authority can be obtained from Congress to bring action against the Government. The only alternative is submission to the arbitrary demands of the Government, which means not only heavy pecuniary loss, but the establishment of a dangerous precedent. The authorities, apparently, seem determined to hold to their present course, and to prevent redress being obtained except by diplomatic interference.

Telegraph Offices.—In the Commons last week Mr. Weir (Ross and Cromarty) asked the Secretary to the Treasury, as representing the Postmaster-General, whether he would state the number of telegraph offices opened under guarantee in England, Wales, Scotland, and Ireland respectively for each year since the transfer of the telegraphs to the State. Mr. Hanbury: I cannot trouble the House by giving verbally, in answer to a question, long strings of figures relating to England, Wales, Scotland, and Ireland separately in each year for more than a quarter of a century, but the information shall be sent to the hon. member.

CONTRACTS OPEN AND CLOSED.

OPEN.

Aberdeen.—April 27th. The Corporation invite tenders for an electrical storage battery consisting of 125 cells of 400 ampere-hour capacity, also for battery regulating switches. City Electrical Engineer, Mr. A. Blackman, Cotton Street.

Aberdeen.—April 27th. The Corporation want tenders for the supply for one year of electricity supply meters, house fuse boxes, and house concentric armoured service cables. City electrical engineer, Mr. Alfred Blackman, Cotton Street, Aberdeen. See our "Official Notices."

Bedford.—The Electric Light Committee want tenders for the supply and erection of two water tube boilers with Vicar's mechanical stokers, alternating current motor, and steam piping. Particulars to be obtained of Mr. T. S. Porter, Town Clerk.

Belgium.—April 29th. Tenders are being invited by the Provincial Government Authorities at Liège for the concession, maintenance, and working of an electric tramway on the overhead-conductor system, between Chenée and Grivegnée. Tenders to be sent to the Gouvernement Provincial à Liège.

Blackburn.—May 1st. The Corporation invites tenders for the supply and erection of electric tramway equipment including two dynamos, switchboard, posts, and bracket arms, overhead line equipment, underground cables, &c., &c. Consulting engineer, Mr. E. M. Lacey, 10, Delahay Street, Westminster, S.W. See our "Official Notices."

Malta.—May 4th. The Receiver-General and Director of Contracts at Valetta invites tenders for a 200 kw. steam alternator, a steam engine to drive same (direct connected), also a water tube boiler. Particulars may be obtained upon application to the Superintendent of Public Works in Malta, or the Crown Agents for the Colonies, Downing Street, London. See our "Official Notices" for further details.

Roumania.—April 19th. The General Direction of the Roumanian Posts and Telegraphs in Bucharest is inviting tenders until April 19th for the supply of 55½ tons of iron wire.

South Africa.—April 17th. Tenders are being invited for the supply of a quantity of porcelain insulators and copper wire. Tenders to be sent to the Consul General of the South African Republic, 8, Doelenstraat, Amsterdam.

St. Pancras.—April 27th. The St. Pancras Vestry want tenders for the wiring, &c., in connection with the electric lighting of the Whitfield Street Baths and Washhouses.

Turkey.—April 21st. The General Direction of the Turkish Posts and Telegraphs in Constantinople is inviting tenders until the 21st inst. for the supply of a quantity of telegraph wire, insulators, &c.

Wallasey.—April 22nd. The Urban District Council want tenders for the supply for one year of sundry supplies, including paper insulated concentric cables; oils, lead and wrought-iron pipes, cast-iron main pipes; cotton waste, meters (gas, water, and electricity); lamp columns and lamps; main switches and cut-outs. Particulars on application at the Gas and Water Engineer's office, at the Works, Great Float, near Birkenhead.

CLOSED.

Blackpool. — The Blackpool Tower Company have accepted the tender of Messrs. Veritys, Ltd., for electrical illuminations to celebrate the Diamond Reign. They have also resolved to accept the same company's tender for a new main dynamo and circuit switchboard.

Portsmouth.—In our last issue we stated that the tender of Messrs. Easton, Anderson & Goolden for motor generators which had been accepted by the Corporation amounted to £1,188 15s. This should have read £1,888 15s.

NOTES.

French Cable Enterprise.—The French press announces the sailing of the cable steamer *Contre Amiral Caubet* on the 2nd inst. from Havre. This vessel, which was described in our issue for April 2nd, has left for La Guayra, the principal port in Venezuela, when she will meet the cable steamer, *Pouyer Quertier*, belonging to the same company, the Société Française des Cables Sousmarins. These two vessels will be engaged in the laying of the Venezuela coast cables, for which the French company is the concessionnaire. In the article on this subject the writer flatters our vanity by referring to us as the best considered journal in this country on matters appertaining to submarine telegraphy. We have always considered that any claim we might have on the kindly thoughts of our readers was derived from our treatment of more recent and more prominent subjects, but we accept as gracefully as may be this additional laurel to our already overcrowded brow.

Personal.—We learn that Mr. Hardie McLean has resigned his position as engineer and manager of the Oxford Electric Lighting Company, and has joined the Board of Messrs. W. Lucy & Co., Limited, the well-known engineers and founders, of Oxford. We understand that the firm, which has been established for over 100 years, are about to commence an electrical department for installation and other work. Messrs. Lucy have been well known in the electrical world for some time as makers of arc lamp columns, and have recently obtained a large contract for a special form of overhead book shelves for the India Office. We wish Mr. McLean every possible success in his new position.

Mr. John Aitchison, one of Messrs. Ernest Scott and Mountain's foremen, has been sent out by that firm on a three years' engagement to Siam, where he is to take charge of some works known as the Bangkok Dock Company. He sailed about three weeks ago.

Lord Rayleigh's Last Lecture.—At the Royal Institution last Saturday, Lord Rayleigh delivered the last of his course of lectures on "Electricity and Electrical Vibrations." After showing an experiment to illustrate electrical resonance, he proceeded, says the *Times*, to discuss those exceedingly rapid electrical vibrations which had been investigated by Hertz and Lodge. For the detection of these, arrangements different from those which sufficed in the case of the vibrations already spoken of were required. Observation of small sparks was the method employed by Hertz himself, who found that when an all but complete metal hoop was within the influence of strong electrical disturbance, minute sparks occurred at the gap. The essential point which he was able to prove experimentally was the wave-propagation of such disturbance, and on the Continent his experiments did much to bring about acceptance of Maxwell's electromagnetic theory of light, though in this country even before them it was generally believed, in accordance with that theory, that light consisted of electrical vibrations of enormous rapidity. After enumerating several considerations which went in favour of this electric theory of light, the lecturer proceeded to describe some other means by which the presence of the Hertzian vibrations might be detected. Rutherford surrounded a small piece of steel, magnetised to saturation, with a helix of wire, the ends of which were connected to long copper rods. The electric waves given off by the oscillator, impinging on these, set up an alternating current in the helix. As the magnet was already saturated, this current could not magnetise it more, but could only produce partial demagnetisation, which would be indicated by a magnetometer. By this device electric waves had been detected at a distance of a mile from their source, and Lord Rayleigh thought that signalling through space without wires in this way might become an important question. Prof. Lodge's coherer, consisting of a tube full of metal filings, was another method of making apparent these vibrations, dependent on their power of improving the electrical contact between the filings, and thus decreasing the electrical resistance of the tube as a whole. What exactly happened in the coherer was not clear, but he thought there was some analogy with what occurred at the meeting of two jets of water; these normally rebounded from each other, but under electric influence they united. A liquid coherer, analogous to the solid one, could be made with a globule of greasy mercury. If this were divided into two globules lying against each other, these would coalesce if a weak current were passed through them, or if a spark were produced in their vicinity. In conclusion, the lecturer said that, while the waves with which Hertz experimented were several metres long, the smallest electric waves yet produced had a length of about 6 millimetres. The next shortest waves known were the dark heat rays of the lower end of the spectrum, but these were still an enormous way from the 6-millimetre electric waves. To bridge over the gap would probably be the work of the next generation of physical investigators.

Institution of Electrical Engineers (Students).—The next visit of the students of the above Institution will be on April 24th, to the works of the City and South London Railway. The party will meet at 195, Clapham Road, at 11 o'clock. As the number will have to be limited, those who wish to attend must send in their names at once to the hon. secretary of the Students' Committee (Mr. W. Bunn, 23, Oxford Road, Stroud Green, N.).

Accidents.—We referred recently to "accidents" as a misnomer, referring to the recent fire at the Union Traction Company in Philadelphia, where a short circuit, caused by a falling chain, set fire to a greasy floor, and the result is termed an accident, and caused a loss of about £55,000. The roof fell in and broke the steam pipes. Steam escaped with a great roar, frightened the horses of a fire engine which bolted and killed two people, and injured 10 to 20 others. 10 to 20 is good. It is one of those little things that shows how the public is treated over there. The fire was discovered soon after 6 p.m. on March 3rd, yet by 10 p.m. all the cars on the lines affected were again able to move, connections having been made with other power houses. The same activity put to the replacing of the greasy floors would have obviated the necessity for this display of energy.

West Ham Inquiry. — Mr. Ernest Baggallay, who recently held a public inquiry into certain allegations with regard to the acceptance by the West Ham Corporation of tenders for the installation of electric lighting in West Ham, has made his report, which was presented, says the *Times*, to the Borough Council at its meeting on Tuesday evening. The first charge was that a Mr. Paris called on the Electric Construction Company and offered to obtain the services of a member of the West Ham Council in getting the contract, for which the councillor would have to be paid, and Mr. Baggallay reported that there was nothing to show that Mr. Paris was acting otherwise than on his own responsibility, and that therefore the nature and object of his call on the company had no importance. The second charge was that Mr. Councillor S. T. Hunns, a member of the sub-committee for the consideration of the tenders, himself made corrupt overtures to the Electric Construction Company, and Mr. Baggallay, in relation to this, said it was not surprising that the Electric Construction Company should have looked upon this visit with suspicion, but the evidence went no further, and he did not find that any corrupt conduct was proved against Mr. Hunns. The last allegation Mr. Baggallay described as the most important. It was that the West Ham Corporation had been corruptly influenced to accept tenders which were not the most advantageous to the borough. The eight tenders accepted amounted to £23,467, and if the lowest tender in each section had been accepted, the total cost would have been £15,704. This difference of £7,763 required some explanation, and Mr. Steinitz, the electrical engineer of the Corporation, upon whose advice and recommendation the sub-committee implicitly relied, was examined upon the tenders at considerable length. His answers satisfied Mr. Baggallay that he had acted throughout with perfect honesty, and that there was no reason whatever for supposing that he had been influenced by any corrupt or improper motive. In conclusion, Mr. Baggallay said that in the absence of evidence of any corrupt action on the part of any member of the Council, which eventually adopted Mr. Steinitz's recommendations, it was no part of his duty to discuss further the results arrived at by the Council. It was enough that he should report that in accepting the tenders the Council selected those which it honestly believed to be the most advantageous, and that the charges entirely failed.

Fatality.—Last Thursday a lad residing at Cambuslang, was killed by the fall of an electric lamp from one of the poles at Morriston skating pond. The lamp struck him on the head.

The Institution of Electrical Engineers.—On Thursday, April 22nd, 1897, the discussion on Mr. A. K. Baylor's paper on "Recent Developments in Electric Traction Appliances" will be continued. After the discussion on Mr. Baylor's paper, the following paper will be read, "The Generation of Electrical Energy for Tramways," by J. S. Raworth, member.

Electro-Hydraulic Dredger.—In the Bates dredger described by the *Engineer*, the dredging is by suction, but rotary cutters and water jets loosen the stuff within the sphere of the suction, and in the machine described as much as 5,000 cubic yards per hour can be dredged. The economic limit of discharge distance is given at 1,000 feet, with an elevation of 35 feet, or 6,000 at water level. The working of the dredge is done by one man from a pilot house, where are all the necessary levers, valves, and switches. The motive power is steam, but the various hoists for the suction pipes, water jet apparatus, anchors, &c., as well as the steering gear, are all electrically operated. There is no more efficient system of dredging than by the suction system, especially in loose material that is apt to be carried away and redeposited by a running tide. In suction dredging all material disturbed is drawn at once to the pipes and deposits in the scows or other provided place and is secured for good. Electric motors ought to be peculiarly suitable for the various machines on a dredger; there is so much hoisting and anchor winch work that the control of a dredge is much simplified when by means of little switches the master can control everything from one spot without any ordering of deck hands.

The Electrical Industry in Cape Colony.—A report on the Electrical and Allied Trades at the Cape is being prepared by Mr. A. P. Trotter, in his capacity as Honorary Correspondent of the London Chamber of Commerce for Cape Colony, and he will allude in the report, among other matters, to the prospects of employment for electrical engineers in South Africa. In the course of a letter to the London Chamber, dated Cape Town, March 24th, Mr. Trotter says:—"My object in writing now is to ask you to make it known as widely as possible through your Journal, and through the technical Press, that no electrical engineers should come out to South Africa at present, unless they have secured definite appointments before sailing. Electrical engineers experienced, and (apparently) otherwise, come to me almost as regularly as the mail, with and without introductions. I regret that I have not been able to give any assistance whatever. Engineers wanting assistants generally send home for them—a very satisfactory course for both parties. I have received letters from electrical engineers of some experience in the Transvaal, that owing to the stagnation of trade, staffs are being reduced, and that many competent men are out of employment."

Physical Laboratory for India.—The following memorial was, on behalf of signatories, including Lord Kelvin, Lord Lister, Profs. Carey-Foster, J. H. Gladstone, J. Hopkinson, W. Ramsay, A. W. Rücker, S P. Thompson, and others, handed to the Secretary for India the other day by Mr. Schwann, M.P.:—"We, the undersigned, interested in the progress of physics, desire respectfully to draw your Lordship's attention to the great importance which we attach to the establishment in the Indian Empire of a central laboratory for advanced teaching and research in connection with the Presidency College, Calcutta, the most important educational institution under the Government of India. We believe that it would not only be beneficial in respect of higher education, but also that it would largely promote the material interests of the country, and we venture to urge on you the desirability, therefore, of establishing in India a physical laboratory worthy of the Great Empire."

Royal Institution of Great Britain.—The following are among the arrangements for Friday evening meetings after Easter:—Friday, April 30th.—Prof. J. J. Thomson, M.A., LL.D., Sc.D., F.R.S., on "Cathode Rays." May 7th.—Anthony Hope, on "Romance." May 14th.—Prof. Harold Dixon, M.A., F.R.S., on "Explosion Flames." May 21st.—The Right Hon. Lord Kelvin, G.C.V.O., D.C.L., LL.D., F.R.S., M.R.I., on "Contact Electricity of Metals." May 28th.—Prof. H. Moissan, Directeur, Laboratoire de Chimie Minérale à l'Ecole Supérieure de Pharmacie, Membre de l'Académie des Sciences, Paris, will lecture in French, on "The Isolation of Fluorine." (With experiments.) June 4th.—W. H. Preece, Esq., C.B, F.R.S., M.Inst.C.E., on "Signalling through Space without Wires." June 11th.—William Crookes, Esq., F.R.S., M.R.I., on "Diamonds." Prof. Dewar will lecture on "Liquid Air as an Agent of Research;" (Three lectures, on Thursdays), May 27th, June 3rd and 10th.

Turin Exhibition, 1898.—On the occasion of the Italian National Exhibition which will be held in Turin from April to October in 1898, to celebrate the 50th anniversary of the proclamation of the Italian Constitution, exhibitors from all countries will be admitted to the special department of electricity. The electrical exhibition will be divided into the following classes:—1. Electric and magnetic school apparatus. 2. Materials and fittings for electrical mains and distributions. 3. Electrical and magnetic testing apparatus. 4. Telegraphs and telephones. 5. Railway signalling and block apparatus. Application of electricity to train lighting and heating. 6. Dynamo-electrical machines and electric motors. 7. Mechanical applications of electricity. Electric traction. 8. Electric lighting. 9. Electro-chemistry and electro-metallurgy. 10. Other applications of electricity. 11. Historical apparatus. Further particulars obtainable on application to the Agente Generale, Angelo Alasia, 3, Via S. Maria, 3, Torino.

Lectures.—At a metting of the East of Scotland Engineering Association on 7th inst., Mr. F. L. Todd read a paper on "Edinburgh Corporation Electric Light Station,"

Easy Inspection of Large Generators.—They seem to be behindhand in the States in some small matters. Thus we read in the *Electrical World* of New York, of an invention of Prof. Sidney H. Short, of Cleveland, Ohio, which has for its object the easy inspection of large generators. It turns out, however, that this *invention* is nothing more or less than racking the field magnet ring of a large dynamo or alternator sideways, to enable one to get at the armature. We wonder how much midnight oil or electricity the professor sacrificed in inventing this marvellous device, used in this country more than five years ago?

The German Electro-Chemical Society.—This Society has arranged to hold its annual meeting this year in Munich on June 21st and following days.

Accident.—At Bristol on Tuesday, at the Corporation Electric Light Works, a pile-driving engine fell on a gang of workmen, of whom one was killed and others injured.

Vacant Appointment.—The Wakefield Town Council want an electrical engineer. See our "Official Notices" for further particulars.

Water Power in Ireland.—The Parliamentary Committee which is considering the Industries (Ireland) Bill, on Friday last took the evidence of Mr. Thomas Halliday, J.P., of Huddersfield, on the possibilities of utilising the water power available in Ireland for electro-chemical and other purposes.

NEW COMPANIES REGISTERED.

Crossley Bros., Limited (51,970).—Registered April 5th with capital of £973,700, in £10 shares (40,339 preference), to acquire the business of Crossley Bros. Limited (incorporated in 1881), to enter into an agreement with the said company and J. W. Cross, its liquidator, and to carry on the business of manufacturers of gas, oil, steam and other engines, mechanical and electrical engineers, millwrights, tool makers, locomotive builders. The subscribers (with one share each) are:—W. J. Crossley, Glenfield, Altrincham, Cheshire, engineer; D. H. Erwin, Woodville Road, Bowdon, Cheshire, engineer; H. P. Holt, 15, Kensington Court, W., engineer; R. Wilson, 7, St. Andrew's Place, Regent's Park, N.W., engineer; A. Simpson, Chaseley, Altrincham, merchant; T. H. P. Crossley, Bordighera, Italy, gentleman; W. H. Irving, Monton, Eccles, Lancashire, cashier; W. S. Huffom, 31, Broomfield Road, Heaton, Chapel, secretary. The number of directors is not to be less than three, nor more than 10; the first are the first five subscribers. Qualification £1,000; remuneration as the company may decide. Registered by Grandy, Kershaw and Co., 4, New Court, Lincoln's Inn, W.C.

"Times" Electric Lamp Company, Limited (52,005).—Registered April 7th with capital £100,000 in £1 shares, to adopt an agreement with W. B. Collyns, jun., and to carry on the business of primary and other battery manufacturers, electric lamp and apparatus manufacturers, electricians, electrical and mechanical engineers, iron and brass founders, &c. The subscribers (with one share each) are:—G. Robins, 28, Harcourt Terrace, W., gentleman; G. A. S. Harrand, 13, Palace Street, Buckingham Gate, gentleman; C. F. Ince, 1, Church Court, Old Jewry, printer; F. Howard, 65, Digby Road, Brownswood Park, N., clerk; H. E. Hill, 8, Grosvenor Terrace, Camberwell, clerk; O. M. Bolton, 431, Liverpool Road, N., clerk; T. Wright, 7, St. Paul's Road, Canonbury, musician. The number of directors is not to be less than three nor more than nine; the first are—S. Macleay, R. G. Webster, H. Lewis, and J. L. Lewis; qualification £200; remuneration £200 each per annum (£300 for the chairman), and a share in the profits. Registered by Lumley and Lumley, 15, Old Jewry Chambers, E.C.

Edmundson's Electricity Corporation, Limited (52,013).—Registered April 7th, with capital £200,000 in £5 shares (4,500 deferred) to adopt an agreement with Edmundson's, Limited, and to carry on the business of electricians, electrical and mechanical engineers, iron founders and fitters, gas engineers, coppersmiths, tinsmiths, lighthouse engineers, &c. The subscribers (with one share each) are:—F. Payton, 19, Great George Street, S.W., secretary; C. H. Jones, Burleigh Mansions, W.C., gentleman; S. K. Thompson, 28, Millbank Street, S.W., electrical engineer; L. A. Hards, 57, Grosvenor Road, S.W., electrical engineer; H. P. Butcher, 54, Lattimore Road, St. Albans, gentleman; E. T. Botwright, 115, Osborne Road, Forest Gate, accountant; W. H. Adams, 168, Friern Road, East Dulwich, accountant. The number of directors is not to be less than three nor more than seven; the subscribers are to appoint the first; qualification £500; remuneration £600 per annum divisible, to be increased to £1,000 per annum when 6 per cent. is paid. Registered office, 19, Great George Street, Westminster.

Electric Supply Corporation, Limited (52,036).—Registered April 8th with a capital of £5,000, in £5 shares, to carry on the business of an electric light and power company in all its branches, electricians, mechanical engineers, suppliers of electricity, &c. The subscribers (with one share each) are: F. R. Reeves, Lochleven House, East Finchley, electrical engineer; H. Stevenson, 119, Oxford Street, W., engineer; C. Peel, 28, Elm Park Road, S.W., electrical engineer; A. Williams, Walcot, East Acton, electrical engineer; H. Walker, 68, South Hill Park, Hampstead, electrical engineer; R. E. B. Crompton, Mansion House Buildings, E.C., engineer; F. Holmes, St. Winifred's, Norbury, S.W., electrical engineer. The number of directors is not to be less than two, nor more than five; the subscribers are to appoint the first; qualification, £100; remuneration, £100 each per annum (£200 for the chairman), and a share in the profits. Registered by F. Reeves, 4, Queen Victoria Street, E.C.

CITY NOTES.

Willans and Robinson, Limited.

The ordinary general meeting of this company was held at Cannon Street Hotel on Wednesday, Mr. Mark Robinson presiding.

The Chairman, in going through the various items of the report, which have already appeared in these columns, spoke of the satisfactory nature of the business, and the increase in the profits. Going to speak of the reserve fund, they had been, he said, accustomed to put by a sum of £2,500 to reserve, but the debenture issue would modify their practice to some extent. It was proposed now to put by £3,000, £2,000 of which would go to a debenture redemption fund, and £1,000 to a reserve fund. The disorganisation of work which must ensue in the removal to Rugby would tell upon both the profit of work and the rate of profit, and they could not expect quite such results next half year that they had been accustomed to. They could not, however, be in a better position to meet a temporary check. The placing of the new issue had been very successfully accomplished; the question of dealing with premiums arising from those shares, £13,000, had required careful consideration, and the directors thought it ought to be applied to writing off the cost of removal to Rugby and to writing off the diminution in the value of assets at Thames Ditton, which would arise through their removal, and if any balance remained it would be devoted to writing off patents accounts. After some further remarks the report and accounts were adopted, and a resolution for a dividend of 6 per cent. on the preference and 7 per cent. on the ordinary was carried.

The retiring directors were re-elected, and the number of directors added to by the election of Lieut.-General Sir Richard H. Sankey and Mr. Thomas Orger Lazenby.

The Great Northern Telegraph Company of Copenhagen.—The net receipts during 1896, including the balance brought forward from 1895, amount to £360,287 7s. 7d. Deducting £63,194 8s. 11d. for interest and amortisation of debentures, and £75,000 for interim dividends already paid, there remains a balance of £222,092 18s. 8d., which the board proposes to distribute as follows:—Final dividend (making the total dividend for the year 10 per cent.), £75,000; reserve and renewal fund, £83,333 6s. 8d.: pension fund of the staff, £2,777 15s. 7d.; directors' remuneration, £1,500; balance to be carried forward, £59,481 16s. 5d.

The Indo-European Telegraph Company, Limited.—The directors, after adding £10,000 to the reserve fund, have determined, subject to audit, to recommend the payment of a dividend for the six months ended December 31st, 1896, of 17s. 6d. per share, making with the interim dividend already paid 6 per cent., and a bonus of 20s. per share, both free of income tax, making in all 10 per cent. for the year. The dividend and bonus will be payable on and after May 1st next.

Victoria Electric Railway Company, Limited.—Messrs. Sperling & Co. notify that they are prepared to take in the debentures of the Victoria Electric Railway Company, Limited, for conversion, on and after the 15th inst., into debentures of the British Columbia Electric Railway Company, Limited. The bonds must be left three clear days for examination, when scrip will be issued for the new bonds, together with cheque for all interest due to date. The new debentures may be to bearer or registered, at option of the holder.

Submarine Cables Trust.—On and after 15th inst. the sum of £2 10s. on account of the coupon due on that date will be paid by Messrs. Glyn, Mills & Co., 67, Lombard Street, between the hours of 10 a.m. and 2 p.m. Coupons should be left with the bankers for examination four clear days before payment.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending April 11th, 1897, were £1,021; week ending April 12th, 1896, £868; increase, £153; total receipts for half-year, 1897, £15,839; corresponding period, 1896, £14,339; increase, £1,500.

The Liverpool Overhead Railway Company. The receipts for the week ending April 11th, 1897, amounted to £1,353; corresponding week last year, £1,469; decrease, £116. 1896 includes Easter week.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending April 9th, 1897, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,165.

SHARE LIST OF ELECTRICAL COMPANIES.

TELEGRAPH AND TELEPHONE COMPANIES.

Present issue.	NAME.	Stock or Share. ‡	Dividends for the last three years. 1894.	1895.	1896.	Closing Quotation, April 7th.	Closing Quotation, April 13th.	Business done during week ended April 13th, 1897. Highest.	Lowest.
175,400£	African Direct Teleg., Ltd., 4 % Deb.	100	4 %	4 %	...	100 —104	100 —104	...	...
25,000	Amazon Telegraph, Limited, shares...	10	...	...	...	4½ — 5½	4½ — 5½	...	...
1,012,880£	Anglo-American Teleg., Ltd.	Stock	£2 2s.	£2 9s.	£2 13s.	50 — 53	49 — 52xd	...	...
2,993,560£	Do. do. 6 % Pref.	Stock	£4 4s.	£4 18s.	£5 6s.	95 — 96	93½ — 94½xd	95½	94⅛
2,993,560£	Do. do. Defd.	Stock	...	...	...	8 — 8¼	7⅞ — 8¼	8	...
139,980	Brasilian Submarine Teleg., Ltd.	10	7 %	7 %	...	15 — 15½	15 — 15½	...	...
75,000£	Do. do. 5 %, Debs., 2nd series, 1906	100	5 %	5 %	...	113 —117	113 —117	...	...
44,000	Chili Telep., Ltd., Nos. 1 to 44,000	5	2½%	4 %	...	3¼ — 3⅜	3¼ — 3⅜	...	...
10,000,000$	Commercial Cable Co.	$100	7 %	7 %	7 %	162 —167	162 —167	...	...
224,850	Consolidated Telep. Const. and Main., Ltd.	10/-	1½%	1½%	...	⅜ — ⅝	⅜ — ⅝	...	...
16,000	Cuba Teleg., Ltd.	10	8 %	8 %	8 %	10 — 11	10 — 11	10½	9½
6,000	Do. 10 % Pref.	10	10 %	10 %	10 %	19 — 20	19 — 20	19½	...
12,931	Direct Spanish Teleg., Ltd.	5	4 %	4 %	4 %	3¼ — 4½	3¼ — 4½xd	...	...
6,000	Do. do. 10 % Cum. Pref.	5	10 %	10 %	10 %	10 — 10½	10 — 10½xd	...	...
80,000£	Do. do. 4½ % Debs. Nos. 1 to 6,000 ...	50	4½%	4½%	4½%	105 —108%	105 —108 %	...	...
60,710	Direct United States Cable, Ltd.	20	2 %	2½%	2½%	8¾ — 9¼	8¾ — 9¼xd	9¼	9
400,000	Eastern Teleg., Ltd., Nos. 1 to 400,000	10	6½%	6½%	...	17 — 17½	17 — 17½xd	17⅜	17⅛
70,000	Do. 6 % Cum. Pref.	10	6 %	6	...	18 — 19	18 — 19 xd	18½	...
102,100£	Do. 5 % Debs., repay. August, 1899	100	5 %	5 %	...	103 —105	103 —106	103½	...
1,297,837£	Do. 4 % Mort. Deb. Stock Red.	Stock	4 %	4 %	...	127 —130	127 —130	...	...
250,000	Eastern Extension, Australasia and China Teleg., Ltd. ...	10	7 %	7 %	%	17⅞ — 18¼	17⅞ — 18¼	18¼	18
54,100£	Do. 5 % (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	5 %	5 %	5%	100 —104	100 —104	103	...
194,300£	Do. do. Bearer, 1,050—3,975 and 4,327—6,400	100	5 %	5 %	5%	101 —104	101 —104	...	...
320,000£	Do. 4 % Deb. Stock	Stock	4 %	4 %	4%	127 —130	127 —130	...	...
80,600£	Eastern and South African Teleg., Ltd., 5 % Mort. Deb. 1900 redeem. ann. drgs., Reg. Nos. 1 to 2,343	100	5 %	5 %	5%	100 —104	100 —104	...	...
107,600£	Do. do. do. to bearer, 2,344 to 5,500	100	5 %	5 %	5%	101 —104	101 —104	...	...
300,000£	Do. 4 % Mort. Debs. Nos. 1 to 3,000, red. 1909	100	4 %	4 %	4%	107 —110	107 —110	...	...
296,600£	Do. 4 % Reg. Mt. Debs. (Mauritius Sub.) 1 to 8,000	25	4 %	4 %	4%	109 —112 %	109 —112 %	110¾	109
180,227	Globe Telegraph and Trust, Ltd.	10	4½%	4½%	...	11 — 11½	11 — 11½	11⅜	11⅛
180,042	Do. do. 6 % Pref.	10	6 %	6 %	...	17 — 17½	17 — 17½	17⅜	...
150,000	Great Northern Teleg. Company of Copenhagen	10	8⅜%	10 %	10%	24 — 25	24 — 25	24⅞	...
180,000£	Do. do. do. 5 % Debs.	100	5 %	5 %	5%	102 —105	102 —105	...	...
17,000	Indo-European Teleg., Ltd.	25	10 %	10 %	10%	55 — 58	55 — 58	...	...
100,000£	London Platino-Brasilian Teleg., Ltd. 6 % Debs.	100	6 %	6 %	6%	107 —110	107 —110	...	...
28,000	Montevideo Telephone 6% Pref., Nos. 1 to 28,000... ...	5	4 %	4 %	...	2 — 2½	2 — 2½	...	...
484,597	National Teleph., Ltd., 1 to 484,597	5	5 %	5½%	5½%	6¼ — 6½	6¼ — 6½	6½	6¼
15,000	Do. 6 % Cum. 1st Pref.	10	6 %	6 %	6 %	15 — 17	15 — 17	16⅛	...
15,000	Do. 6 % Cum. 2nd Pref.	10	6 %	6 %	6 %	16 — 18	15 — 17	...	...
119,234	Do. 5 % Non-cum. 3rd Pref., 1 to 119,234	5	5 %	5 %	5 %	6 — 6½	6 — 6½	6	...
1,100,000£	Do. 3½ % Deb. Stock Red.	Stock	3½%	3½%	3½%	102 —105	102 —105	102½	...
171,504	Oriental Teleph. & Elec., Ltd., Nos. 1 to 171,504, fully paid	1	4½%	5 %	...	⅝ — ¾	⅝ — ¾	...	...
100,000£	Pacific and European Tel., Ltd., 4 % Guar. Debs, 1 to 1,000	100	4 %	4 %	4%	107 —110	107 —110	...	...
11,839	Reuter's Ltd.	8	nil	5 %	...	7 — 8	7 — 8	7 1/16	7
3,381	Submarine Cables Trust	Cert.	...	...	...	138 —143	138 —143	...	...
58,860	United River Plate Teleph., Ltd.	5	3 %	4 %	...	3 — 3½	3 — 3½	...	...
146,735£	Do. do. 5 % Debs.	Stock	5 %	5 %	...	100 —105	100 —105	...	...
15,609	West African Teleg., Ltd., 7,501 to 23,109	10	nil	4 %	...	5 — 6	5 — 6	...	...
238,800£	Do. do. do. 5 % Debs.	100	5 %	5 %	...	101 —104	101 —104	...	...
39,000	West Coast of America Teleg., Ltd.	10	nil	nil	...	⅜ — 1¼	⅜ — 1¼	...	...
158,000£	Do. do. do. 8 % Debs., repay. 1902	100	8 %	8 %	...	103 —108	103 —108	...	...
54,248	Western and Brasilian Teleg., Ltd.	15	3 %	3 %	...	7⅜ — 8¼	7⅜ — 8¼	...	...
33,129	Do. do. do. 5 % Pref. Ord. ...	7½	5 %	5 %	...	6¼ — 6⅝	6¼ — 6⅝	...	...
33,129	Do. do. do. Def. Ord.	7½	1 %	1 %	...	1⅜ — 2¼	1⅜ — 2¼	...	...
165,280£	Do. do. do. 6 % Debs. "A," 1880 Red.	100	6 %	6 %	...	112 —116	112 —116	...	...
206,400£	Do. do. do. do "B," do.	100	6 %	6 %	...	109 —113	109 —113	...	...
88,321	West India and Panama Teleg., Ltd.	10	1½%	1½%	...	⅞ — 1⅛	⅞ — 1⅛	1 1/16	...
34,563	Do. do. do. 6 % Cum. 1st Pref.	10	6 %	6 %	...	11 — 11½	11 — 11½	11⅜	...
4,569	Do. do. do. 6 % Cum. 2nd Pref.	10	6 %	6 %	...	9½ — 10½	9½ — 10½	...	...
88,660£	Do. do. 5 % Debs. No. 1 to 1,800 ...	100	5 %	5 %	...	107 —110	107 —110	...	...
1,777,000$	Western Union of U. S. Teleg., 7 % 1st Mort. Bonds ...	$1000	7 %	7 %	7%	107 —112	107 —112	...	...
164,300£	Do. do. 6 % Ster. Bonds.	100	6 %	6 %	6%	100 —105	100 —105	...	...

ELECTRICITY SUPPLY COMPANIES.

30,000	Charing Cross and Strand Electy. Supply	5	4½%	5 %	6 %	10½ — 11½	10½ — 11½	11⅛	10 1/16
10,277	*Chelsea Electricity Supply, Ltd., Ord., Nos. 1 to 10,277 ...	5	5 %	5 %	5 %	8⅞ — 9¼	8⅞ — 9¼	9⅛	8 15/16
60,000	Do. do. do. 4½ % Deb. Stock Red. ...	Stock	...	4½%	4½%	112 —115	112 —115	...	...
40,000	City of London Elec. Lightg. Co., Ltd., Ord. 40,001—80,000	10	5 %	5 %	7 %	19 — 20	21 — 22	21⅜	19⅝
40,000	Do. do. 6 % Cum. Pref., 1 to 40,000	10	6 %	6 %	6 %	16½ — 17½	16½ — 17½	17	16 15/16
300,000	Do. 5 % Deb. Stock, Scrip. (iss. at £115) all paid	...	5 %	5 %	5 %	132 —136	132 —136	...	...
22,475	County of Lond. & Brush Prov. E. Ltg. Ltd., Ord. 1—22,475	10	...	nil	nil	11½ — 12	11½ — 12	12	11⅞
20,000	Do. do. do. 6% Pref., 40,001—50,000 ...	10	...	6 %	6 %	14½ — 15	14½ — 15	14⅞	14⅜
10,000	Do. do. do. iss. at 2 pm., all paid	10	...	...	...	14½ — 14⅝	14½ — 14⅝	14⅝	14⅜
49,900	*Metropolitan Electric Supply, Ltd., 101 to 50,000 ...	10	3 %	4 %	...	15½ — 16½	16 — 17	16⅝	15 13/16
12,500	Do. Ord., 50,001—62,500, iss. at £2 prem. ...	10	...	...	...	11½ — 12½	12 — 13	12 1/16	12¼
150,000£	Do. 4½% first mortgage debenture stock	...	4½%	4½%	...	120 —124	120 —124	...	...
5,452	Notting Hill Electric Lightg. Co., Ltd.	10	1 %	2 %	4 %	11½ — 12½	12 — 13	12⅜	12
19,980	*St. James's & Pall Mall Elec. Light Co., Ltd., Ord., 101-20,080	5	6½%	7½%	10½%	14 — 15	14½ — 15½	15⅜	14⅜
20,000	Do. do. 7 % Pref., 20,081 to 40,080	5	7 %	7 %	7 %	9½ — 10½	9½ — 10½	...	...
50,000	Do. do. 4 % Deb. stock Red. ...	Stock	...	...	...	104 —107	104 —107	...	...
67,900	*Westminster Electric Supply Corp., Ord., 101 to 60,000 ...	5	5 %	7 %	9 %	13½ — 14½	13½ — 14½	14⅛	13 11/16

* Subject to Founder's Shares. † Quotations on Liverpool Stock Exchange.

‡ Unless otherwise stated all shares are fully paid. ‖ Dividends paid in deferred share warrants, profits being used as capital.

§ Dividends marked § are for a year consisting of the latter part of one year and the first part of the next.

SHARE LIST OF ELECTRICAL COMPANIES—*Continued.*

ELECTRICAL RAILWAY, MANUFACTURING, AND INDUSTRIAL, COMPANIES.

Present Issue.	NAME.	Stock or Share ‡	Dividends for the last three years. 1894.	1895.	1896	Closing Quotation, April 7th.	Closing Quotation April 13th.	Business done during week ended April 13th, 1897. Highest.	Lowest
90,000	Brush Elecl. Enging. Co., Ord., 1 to 90,000...	3	2½%	...	...	¾ – 1	¾ – 1	1⅛	...
90,000	Do. do. Non-cum. 6 % Pref., 1 to 90,000	2	3 %	...	...	1½ – 1⅝	1½ – 1⅝	1½	1⅜
125,000‖	Do. do. 4½ % Perp. Deb. Stock.	Stock	4½%	...	...	104 —108	104 —108	...	...
76,770	Do. do. 4½% 2nd Deb. Stock Red. ...	Stock	...	...	...	95 — 99	95 — 99	...	...
9,104	Central London Railway, Ord. Shares	10	...	...	...	9½ — 10	9½ — 10	...	...
207,649	Do. do. do. £6 paid	10	...	...	...	5½ — 6	5½ — 6	...	...
630,000‖	City and South London Railway	Stock	1½%	1 3/16%	1 9/16%	59 — 61	59 — 61	60	59½
28,180	Crompton & Co., Ltd., 7 % Cum. Pref. Shares, 1 to 28,180	5	*nil*	*nil*	...	1⅝ – 2¼	1⅝ – 2¼	...	...
89,261	Edison & Swan United Elec. Lgt., Ltd., "A" shrs, £3 pd. 1 to 89,261	5	5 %	5 %	...	1⅝ — 2¼	1⅝ — 2¼	...	...
17,139	Do. do. do. "A" Shares 01—017,139	5	5 %	5 %	...	3 — 4	3 — 4	...	...
100,000	Do. do. do. 4½% Deb. Stock Red. ...	Stock	4½%	4½%	...	106 —110	105 —110	...	...
110,000	Electric Construction, Ltd., 1 to 110,000	2	*nil*	5 %	...	1½ – 1¾	1½ – 1¾	...	...
12,845	Do. do. 7 % Cum. Pref., 1 to 12,845 ...	2	7 %	7 %	...	2⅜ – 3¼	2⅜ – 3¼	...	...
91,195	Elmore's Patent Cop. Deposg., Ltd., 1 to 70,000	2	*nil*	...	...	⅞ – 1⅛	⅞ — 1	...	...
69,385	Elmore's Wire Mfg., Ltd., 1 to 69,385, issued at 1 pm. ...	2	*nil*	...	...	⅜ – ⅝	¼ — ½	...	...
9,600‖	Greenwood & Batley, Ltd., 7 % Cum. Pref., 1 to 9,600 ...	10	*nil*	10½%	...	12 — 14	11 — 13	...	...
10,000	Henley's (W. T.) Telegraph Works, Ltd., Ord.	10	6 %	8 %	10 %	19 — 20	19 — 20	19½	19
3,000	Do. do. do. 7% Pref.	10	7 %	7 %	7 %	18½ – 19½	18½ – 19½	...	...
50,000	Do. do. do. 4½ Mort. Deb. Stock	Stock	...	4½%	4½%	107 —112	107 —112	...	...
56,000	India-Rubber, Gutta Percha and Teleg. Works, Ltd. ...	10	10 %	10 %	10 %	20½ – 21½	20½ — 21½	21¼	21⅛
300,000	Do. do. do. 4 % 1st Mort. Debs.	100	...	...	...	104 —107	104 —107	...	...
37,500	†Liverpool Overhead Railway, Ord.	10	1½%	2⅝%	2⅞%	12 13/16 – 12 15/16	12⅞ – 13	...	...
10,000	† Do. do. Pref., £10 paid	10	5 %	5 %	5 %	16⅛ – 16⅝	16⅛ – 16⅝	...	...
37,350	Telegraph Constn. and Maintce., Ltd.	12	20 %	15 %	15 %	34 — 37	34 — 37	36½	34½
150,000	Do. do. do. 5 % Bonds, rel. 1899	100	5 %	5 %	5 %	103 —106	103 —106	104½	...
54,000‖	Waterloo and City Railway, Nos. 1 to 54,000, £8 paid ...	10	...	...	...	10⅜ – 11¼	10⅜ – 11¼	11 3/16	11

Quotations on Liverpool Stock Exchange. ‡ Unless otherwise stated all shares are fully paid. ¶ Last dividend paid was 50 % for 1890.
Dividends marked ‖ are for a year consisting of the latter part of one year and the first part of the next.
Crompton & Co.—The dividends paid on the ordinary shares (which have not a Stock Exchange quotation), are as follows: 1892—0%; 1891—7½%; 1890—8%

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Birmingham Electric Supply Company, Ordinary of £5 (£4 paid), 7⅞, £5 (fully paid) 9⅛.
Electric Construction Corporation, 6 % Debentures, 103—106.
House-to-House Company (£5 paid), 7¼—7⅜.
Do. do. 7 % Preference, of £5, 9¼—9⅜.
Do. do. 4½% Debentures of £100, 108—110.
* From Birmingham Share List.

Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid) 11½—12; 1st Preference Cumulative 6 %, £5 (fully paid), 8—8½. Dividend, 1896, on Ordinary Shares 7 %.
London Electric Supply Corporation, £5 Ordinary, 1½—1⅝.
Yorkshire House-to-House Electricity Company, £5 Ordinary Shares fully paid, 8¼—8⅜. Dividend for 1896—6 %.

Bank rate of discount, 2½ per cent. (April 8th, 1897).

EQUALISING CONNECTIONS FOR COMPOUND-WOUND DYNAMOS COUPLED IN MULTIPLE.*

By E. R. KELLER.

The successful operation of stations for electric lighting and power depends largely on the automatic regulation, not only of the speed of the prime movers, but also of the E.M.F. of the generators. In both of these essential features the last few years have brought forth marked development, in consequence of which we are now enabled to instal plants for electric lighting and power, in which the speed of the engines will not vary more than 1½ per cent. from the normal, when the full load is suddenly thrown on or off, while the builders of dynamo machinery can and do supply us with generators which are almost absolutely self-regulating as to E.M.F. A modern constant potential generator will not only compensate automatically for the variable losses due to armature reaction and internal resistance, but it can be made to give an E.M.F. at the brushes which, under varying conditions of load, will be such as to compensate not only for the variable losses in the machine itself, but also those due to the resistance of the external circuit.

The success which has thus been attained in the automatic regulation of constant potential generators is largely due to the careful study and application of compound winding; and while but a few years since nearly all of the large stations were equipped with plain shunt-wound generators, we find that these have now been superseded by the compound-wound type, in almost every class of service.

This change from shunt to compound winding has necessitated a slight modification in the connections from dynamo to switchboard, where two or more generators are coupled in parallel. For such an arrangement of generators we must employ an additional conductor between the generators commonly called the equaliser or tie line, whose function it is primarily to prevent a possible reversal of polarity of any of the machines, and further to equalise to some extent the output of each machine under varying conditions of the external load or speed of the prime movers.

That this connection is absolutely an essential for the successful operation of compound wound generators in multiple is beyond dispute. On the other hand, there has been a great deal of dispute in regard to what strength of current it may be called upon to transmit. In fact, its mode of action does not seem to be entirely clear to many engineers who are perfectly familiar with the installation of dynamo machinery, and who would not think of omitting the equaliser where two or more compound machines are to be used in multiple. I desire to submit a mechanical analogy, which, though deficient in many of its details, will serve to show the action of compound machines together with the equaliser connection and the function which it has to perform.

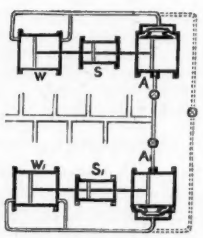


Fig. 1.

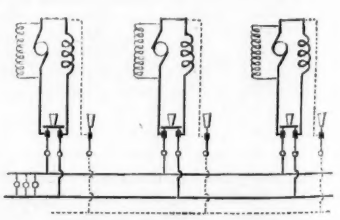


Fig. 2.

Consider, for a moment, the arrangement shown in fig. 1. We have two direct-acting steam pumps located at different points along a system of distributing mains. These pumps consist of a steam cylinder, s, a water cylinder, w, and an

* Read before the Electrical Section of the Franklin Institute, and reproduced from the *Journal*.

auxiliary cylinder, A, through which all the water passes before it enters the supply mains. There would be no particular utility for such an auxiliary cylinder in a pump; in fact, unless the details of such an arrangement are carefully worked out, it is more than likely that such a combination would not work at all; it will suffice, however, for the sake of the analogy, and we will assume that the details are so arranged that the mechanism will operate in the manner desired. Suppose now we have a steam pressure of 100 lbs. per square inch in the steam cylinder, a pressure of 70 lbs. in the cylinder, W, and 60 lbs. at the beginning of the supply mains under normal conditions. The 10 lbs. difference between the 70 lbs. and 60 lbs. acting on either side of the auxiliary piston, which is intended to act in a manner similar to an hydraulic engine, will help the steam piston along, and so long as the two machines continue to act under normal conditions, everything will go smoothly, each machine taking its share of the load. But now suppose that the steam pressure in one of the engines should fall to, say, 95 lbs. We would immediately have a corresponding drop of pressure in W to, say, 65 lbs., while in the supply mains the pressure would still remain constant. We would now have an effective pressure of only 5 lbs. in the auxiliary cylinder instead of 10 lbs., and consequently a still greater reduction of pressure in W. This, in turn, would still further diminish the effective pressure in A, and so on. Presently the back pressure from the main will be greater than the forward pressure in A, and if the difference becomes sufficiently great, the action of the auxiliary cylinder will overpower that of the steam cylinder, and the whole mechanism will be driven backwards by the water pressure in the mains. The machine will not only cease to contribute its share of water to the supply mains, but will actually consume enough to operate it as a motor, and thus make considerably more work for the other machine.

To avoid the possibility of this reversal taking place, we connect the water pipes where they enter the auxiliary cylinders, as shown by the dotted lines. If we make this tie line sufficiently large, there will always be supplied enough pressure to the front of the auxiliary piston to prevent the pressure in the mains from reversing the mechanism, and furthermore, to equalise in a measure the work done by each unit, under varying conditions—the equalisation being the more complete, the larger the tie line.

This is precisely what takes place in compound or series-wound generators; and if we consider the cylinders, W, as replaced by armatures, the auxiliary cylinder by series or compound windings, the steam cylinders by the shunt windings, and the steam pressure acting on the piston by the speed of rotation of the armatures, we have two compound-wound generators coupled in parallel.

Fig. 2 shows this arrangement as commonly used. The equaliser connection, as here shown by the dotted lines, was first suggested by Gramme for series machines, and by Mordey for compound. If made sufficiently heavy, it will not only effectually prevent the reversal of polarity of any

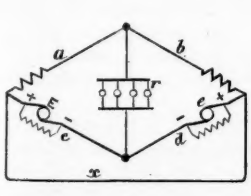


Fig. 3.

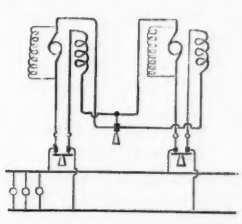


Fig. 4.

of the machines so connected, but will, in a great measure, equalise the work done by the generators under varying conditions of speed. Any number of dynamos may be connected up in this manner, and even if they are of different capacities, each machine will give current in proportion to its rated output, provided the combined resistances of the leads to the bus bars, the armatures and the series fields, are inversely proportional to the ampere capacities of the machines. Without the equaliser connections, or if these are not sufficiently heavy, a change of speed or of load is liable to produce a reversal of polarity in the deficient machine, in which case it will run as a motor, supplying none of its share of the current, but, on the contrary, making an additional load for the other machines, and perhaps causing a costly interruption in the operation of the plant.

The question now arises—how shall we proportion the equaliser connection?

In fig. 3 we have a diagrammatic representation of two compound-wound generators of equal capacities, in parallel, supplying current to a common line of resistance, r, and having an equaliser connection of resistance, x. So long as the E.M.Fs. generated by the two machines are the same, equal currents will flow through the series fields and there will be no current in the tie line. If, however, the E.M.F. (E) of one machine becomes greater than that (e) of the other, there will immediately be a greater current in the series fields of the machine generating the higher E.M.F., and a flow of current in the tie line tending to equalise the currents in the series fields, which current we will call X. But this flow of current in the equaliser will cause a fall of potential = X x, and so long as there is a fall of potential in this line, the currents in the series windings, which we will call A and B respectively, can never be equal. Hence, it

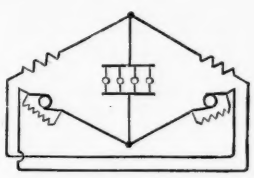


Fig. 5.

follows that we can only have A equal to B when $x = o$, which is evidently impossible.

A little consideration will further show that even if we could make $x = o$, we would not have succeeded in equalising the currents in the armatures, but merely those in the series windings, because, if there is any inequality in the E.M.Fs., that armature which is generating the higher will carry not only the current in its own series windings, but, in addition, that supplied to the other machine to make the two equal. That is, it will carry a current C = A + X, while the other armature carries only D = B − X. In other words, if the resistance of the equaliser could be made equal to zero, so that A = B, one armature would carry more current than the other by an amount equal to twice that in the equaliser.

It is evident, therefore, that in this method we effectually prevent the reversal of polarity of any of the machines so connected, while we only tend to equalise the currents in the series windings, the tendency being the more nearly realised, the less the resistance of the tie line.

There is another method of attaining this end, and one which, if it could be successfully applied, would attain it much more perfectly. This method, which is an old one, is illustrated in figs. 4 and 5.

It consists in passing the current of one armature around the series coils of the other machine, and *vice versâ*. The method is perfectly feasible, and the mutual action of the output and strength of field of the two machines insures an equal division of the load.

Fig. 4 shows how this might be arranged at the switch-board, and it will be seen that by closing the single pole switch either machine could be operated alone. Unfortunately, however, this system can be used only for two machines, and moreover, these two must be exactly alike both in capacity and design. As this state of affairs rarely occurs in practice, the method has but little value.

Returning now to the consideration of the first-mentioned method, let us see what will be the distribution of the currents for given resistances, and for varying values of the E.M.F.

(To be continued.)

REVIEWS.

*Les Accumulateurs Electriques.** By F. Loppe, Ingénieur des Arts et Manufactures. Paris: Gauthier-Villars et Fils, and Masson et Cie, Boulevard Saint-Germain.

(*Concluded from page* 486.)

It was long ago pointed out that the electromotive force between lead and chemically produced peroxide of lead is lower than that with electrolytically produced peroxide. An observation of M. Darrieus is reproduced as follows: "If a grid be partly oxidised" (peroxidised) "by immersing it for instance in a boiling solution of hyposulphite" (hypochlorite) "of soda, an E.M.F. of 1·65 v. is obtained. If it be (partly) peroxidised by electrolytic means, 1·95 v. is obtained."

A very complete table is given, expressing the relation between the specific gravity of the acid electrolyte and the percentages of H_2SO_4 and SO_3 contained in it.

The contradictory experimental results obtained in relation to the quantity of H_2SO_4 absorbed per ampere hour are referred to. Taking the ampere hour equivalent of monohydrated sulphuric acid as 1·83 gramme, the weight of this acid absorbed per ampere hour should be according to the double sulphation theory, 3·66 grammes. The following results, however, were obtained by M. Roux:

The spongy lead plate absorbed	...	...	1·410 gramme.
The peroxide plate absorbed	...	...	2·293 „
Total	...	...	3·703

or just about the correct value which should be equally distributed between the two plates. A misprint in the book makes this value 3·86 grammes.

M. Darrieus, on the other hand, finds, as the result of a large number of trials, that only 1·83 grammes of the acid is absorbed per ampere hour. This would be in accordance with the single sulphation theory. And M. Drzewiecki finds that 2·75 grains are absorbed, or about one and a half equivalent. It is to be hoped that such contradictory results may be reconciled by taking into due and instructive account certain probable differences in the conditions of the experiments.

The variation of the electromotive force with the degree of concentration of the electrolyte is treated at considerable length; but, as the information brought forward is derived from British sources familiar to our readers, we need not devote space to this portion of the work. The curious perversity exhibited by our neighbours *d'outre Manche* in mis-spelling British names is here repeatedly illustrated by references to "MM. Gladstone and Hippert."

The portion of the book—extending over 91 pages—which is devoted to industrial accumulators, sets out with the old mistake that *lithanode* is compressed peroxide of lead. The elements manufactured by M. Carl Hering, and the positive plates of the Verdier and Atlas accumulators, complete the list of "homogeneous electrodes."

The section devoted to "electrodes of autogenous formation," commences with an interesting exposition of the conditions which determine the increase in volume (*foisonnement*) in the electrolytic "formation" of lead plates. The mean coefficients for the linear expansion attending the production of active material are given as 1·26 for the positive plate (on the hypothesis that half of the active material is converted into sulphate during discharge), and 1·27 for the negative plate.

We notice that the author assumes that the lead-antimony alloy (ascribed to Mr. Sellon), the alloy of lead, antimony and mercury (Julien), and that of lead with cadmium (L. James), are all three "inattackable by electrolysis." Those of our readers who have had experience in this direction will, we think, confirm our own conclusion that the contrary is, emphatically, the case. Under this section the accumulators of Planté, of Tommasi (1881), of Kabath, of Arnould and Tamine, of Simmen, of Reynier (1883), of Monnier, of Howell, of Schoop, the positive electrodes of Dujardin, the accumulator of M. Peyrnsson, and, lastly, that of M. Blot, receive ample consideration.

In the section on "Accumulators of Heterogeneous Formation," the deposition processes of Montaud, Schoop, "Brusch" and Dujardin are first referred to. The remainder of the section is devoted to the "pasted" accumulators of Faure, of Rousseau, of James, of Pollak, the Faure-Sellon-Volckmar or E.P.S. accumulator, the elements of Julien and Gadot, the "Chloride" accumulator of Laurent Cély, the grooved elements of Tudor and Khotinsky, the "trough" support used in the Paris tramcars, the Correns grid and that of M. Hagen, and the Fulmen element enveloped in perforated celluloid.

In the section on "The Accumulator Element" (or cell) the use of peroxide of hydrogen and of salts of soda or ammonia is unhesitatingly condemned. "At the present time," says M. Loppé, "these processes (additions), which practically are of no utility, have been completely abandonded, and sulphuric acid and water are alone used to constitute the electrolyte." We are under the impression, however, that the addition of sulphate of soda to the electrolyte is still to some extent adhered to in England.

The maximum density of the electrolyte after charge should not, it is stated, exceed 30 degrees Baumé (sp. g. 1·263); otherwise detrimental sulphation and local action upon the spongy lead are to be apprehended.

The section on "The installation and mounting of a battery" contains useful information which is not of a novel character, with the exception of the statement that in batteries for lighting vehicles or for traction, the capacity should be as high as 10 ampere-hours per kilogram of accumulator, *i.e.*, 4·54 amp.-hour per lb. This is at the normal rate of discharge which is taken as ·5 amp. per kilo. of accumulator, or ·227 amp. per lb. What should be the *safe* rate of discharge—a very interesting datum—is not stated. In our view it should be quite four times higher than the normal rate given above; although this normal rate is somewhat higher than the safe rate of the old E.P.S. "L" accumulator.

Under the section, "Maintenance of a Battery," M. Loppé falls into the old error of ascribing the effect of sulphation —or "sulphatation" (*sulfatation*), as he more properly calls it —to the production of a basic sulphate of lead (Pb_2SO_5) which, it is supposed, is reduced to spongy lead, or converted into peroxide only with great difficulty. It must be further supposed by those who adopt this view, that the normal sulphate ($PbSO_4$) is reduced or peroxidised with comparative facility. Not only is it well known to every electro-chemist that the contrary is the case, but a very slight acquaintance with thermal chemistry, with the figures quoted above from M. Loppé, show that it must be so—that Pb_3SO_5 evolves 10·7 kilocalories by becoming converted into 2 $PbSO_4$, that the heat of constitution if one equivalent of the latter compound is considerably higher than that of the former, and that, consequently, the basic salt must be more readily electrolysed than the normal salt. This, unless it be in intimate admixture with a conductor, such as residual spongy lead or peroxide, is, in fact, scarcely susceptible of electrolysis.

The fifth portion of the work on "Special Apparatus" contains useful information mainly derived from British sources. The sixth and last division on "Measurements," gives a condenser method of determining the internal resistance of an accumulator, which is a modification of that of Munro, attributed to M. Roux. It also describes an interesting and, we think, but little known method, devised by M. Schoop, of determining the relative effect of the two electrodes of a cell upon its internal resistance.

The work of M. Loppé is undoubtedly, in our opinion, the most advanced and useful text-book on electrical accumulators which has hitherto appeared, a fact which would have justified us in devoting even a larger portion of our space to the notice of its most salient points of interest.

D. G. F-G.

Power Distribution for Electric Railroads. By Louis Bell, Ph.D. New York: Street Railway Publishing Company.

This is an excellent book, and easily takes first place amongst kindred publications so far issued, just as Dr. Bell's previous work on electric traction generally (written in conjunction with Mr. Crosby) has remained the leading treatise for practical value and information, if only by reason of its original investigation and research into most of the problems of electric traction work, as distinguished from the mere

* The present work forms part of the "Encyclopédie Scientifique des Aide-Mémoire," published under the direction of M. Léauté, Membre de l'Institut.

paste and scissor descriptions of apparatus, and the historical particulars, that have too often been dignified by the name of "Hand-book to Electric Traction."

In this present work, Dr. Bell has specialised one particular branch of the general subject, viz., the circuits out and home; and so well is it dealt with, that we are obliged at the outset to express a hope that Dr. Bell will in similar fashion take up the questions referring to power-house design and construction, rolling stock and gear, &c. Guides to the best and newest information on these points are just as necessary and needed as the book now before us, and the author is well able to undertake the task, if we may judge from the present instance.

While saying that the subject of power distribution is thus admirably treated, we do not imply that those who want mere constructive details will find them here. As a matter of fact, overhead construction is hardly touched upon, in the sense of describing the various parts and elements; these are presumed to be known, seeing that the author writes for engineers, and not learners; and we value the book all the more for this, since the pages are not filled up with details of this kind of pole, or that make of trolley car and section insulator. Particulars of this nature are best got from a set of trade circulars or advertisements.

On the general subject of power distribution, Dr. Bell, of course, has to admit the enormous concurrent fluctuations, not only in load, but also distance of transmission, and the equations for corresponding circuits—lead and return—are therefore confessedly only approximate. But they will still give, if followed out, a degree of accuracy not hitherto attempted by many engineers in dealing with this branch of their work. It is no small help to have the limits of equations set out, even with numerous assumptions. The fundamental equations are, of course, in the form of $c.\,m. = \frac{11\ C\ L}{E}$, where $c.\,m.$ stands for the conductor section in circular mils; 11 is the copper resistance constant, varying up to 14, which figure is preferable for ordinary working conditions; C is the current passing; L the length in feet of complete circuit, and E the drop in volts; and secondly, $W = \frac{K\ C\ L^2 m}{E}$ where W is the weight of copper conductor in pounds; K the copper constant, ranging from 33 to 42, preferably the latter; C is current; L m the circuit length in thousands of feet. These equations Dr. Bell uses throughout as a base for calculations.

The proper centre of supply is shown to be practically equivalent to the centre of gravity of average loads, the limits of deviation from this being discussed in regard to the ultimate choice of site for a power house in any traction system. "The conductors are to be so distributed as to prevent the system breaking down when loaded in some abnormal manner at some unusual point." This is the task set before the traction engineer at the outset; and we do not, therefore, wonder at Dr. Bell adding: "No theory can take account of such occurrences; their ill effects can be obviated only by good judgment, which is of more value than many theories." Nevertheless, by careful balancing of capital and working costs, the engineer can usually find a safe course to follow, unless absolutely restricted in any one particular direction.

In dealing with the return circuit, Dr. Bell reckons the resistance per bond complete at each rail joint to be about ·0045 ohm, for well made contacts, and bonds equal to No. 0000 gauge. The total resistance of bonds and contacts probably reaches twice the resistance of the rails themselves. He states his conviction to be—and we strongly agree with him—that electrolytic troubles are best prevented (they should not need "curing") by an efficient rail return circuit. There is no reason why the track should not serve perfectly well, and with, say, only 1 per cent. of the current straying to earth, the electrolytic action, while not absolutely suppressed, would be so slow and trifling as only to require notice at a few points where special protection could be given. The entire resistance of a double track road with 90 lb. rails should not exceed ·0087 ohm per mile.

The questions concerning direct feeder systems are treated very carefully and completely by Dr. Bell with great analytical skill; and the various steps shown very clearly in an example of feeder design for an assumed network and conditions are characterised by minute attention to every detail. One conclusion that the author comes to is, that if the engineer takes care of the maximum loads in calculating out the feeders, the average loads will take care of themselves. This does not, however, mean that all one has to do is to allow sufficient margin: differences in distribution as well as differences in load have to be considered.

"Special methods of distribution" bring us to the consideration of using higher voltages than the usual 500; and to show the importance of the subject, Dr. Bell mentions that to deliver 500 amperes at 10 miles distance with 150 volts drop, at least 150 tons of copper would be required. The methods of increasing the pressure thus introduced include, first, the "booster" system, which consists of an extra machine in series with the generating supply, increasing it by 50 per cent. or so (thus justifying its French name of "Survolteur"); and in cases of long distance transmission, it pays, as a rule, to instal a booster rather than extra feeders, when the heavy load comes on for a few hours only. The booster is well suited for tiding over the times of unusually heavy traffic, but has nevertheless strongly marked limits of usefulness. Secondly, there is the three-wire system, necessitating, however, either two trolley wires, or the frequent breaking up of a single trolley into sections alternately + and −, but even here there must be considerable unbalance, whilst in the former case the considerable conductivity of the track is only used when it acts as neutral wire on a state of unbalance. At the same time, electrolytic action is much reduced. Several other modifications are also dealt with, such as a proposal to put two trolleys on each car, which is therefore a balanced unit in itself, the motors taking current from the + and — wires respectively with which the trolleys are in contact.

(To be continued.)

THE TRANSMISSION OF POWER TO LONG DISTANCES BY ALTERNATING CURRENTS OF ELECTRICITY.*

By W. B. ESSON, M.Inst.C.E., M.I.E.E., &c.

(*Continued from page* 510.)

The current being ascertained, the volts which it is permissible to lose in the line will determine the size of the conductors. In Table II. are given the volts lost in the conductors per mile of transmission for different current densities, and from this, knowing the fall of pressure allowable, the best density to work at can be determined.

If the plant is three-phase the volts lost per mile must be taken as half of what is given in Table II. Table III. furnishes us with the size of conductor for carrying any current at any density, and thus supplies the final figure for the line.

Table II.

Volts lost per Mile at Different Current Densities.

Amperes per square inch of section of conductor.	Loss of pressure in volts per mile.
2,000	172
1,500	130
1,000	86
800	69
700	60
600	52
500	43
400	34
300	26
200	17 2

In giving these figures I have simplified matters by ignoring the effects of the self and mutual induction of the line wires, but it must be understood that these are, in many cases, by no means negligible, especially in long distances with heavy conductors.

I have spent so much time on the line that there remains but little more for the motors. In concluding this section, I must just say that in no case should the conductor be less than No. 10 gauge, on account of the liability of smaller wire to get damaged by storms, while practical considerations place the other limit at about $\frac{37}{14}$'s stranded. If a greater area is required it should be divided between two or more conductors. With this size of cable by two-phases, under ordinary circumstances about 1,500 horse-power may be transmitted.

* Paper read before the Society of Arts on Wednesday, March 24th, 1897. From the Society of Arts *Journal*.

III.—Motors.

On referring to the classification at the beginning of this paper, it will be seen that there are two types of motors, synchronous and non-synchronous, and in their action these, in several important particulars, are unlike. I set down below in parallel columns the chief points of difference, thus:—

Synchronous.	*Non-Synchronous.*
1. Requires direct current exciter, and has consequently a direct current commutator.	Does not require exciter, and has therefore no commutator.
2. Will only start with fraction of load.	Will start with full load with two or three phases.
3. Runs always at same speed.	Speed drops as the load is increased.
4. Has a power factor at full load of nearly unity.	Has a power factor at full load of from ·65 to ·85, according to size.

The first point is that synchronous motors require exciters. Such motors, as you are probably aware, are constructed on the same lines as alternators, whether for single, two or three-phase currents; in fact, they are alternators running as motors instead of generators. They must therefore have a direct current machine to excite their field magnets, and this means a commutator as well as a pair of contact rings to keep in repair. The non-synchronous motor, on the other hand, requires no exciter, the E.M.F. in the armature windings being induced by the action of the oscillating or rotating field. On this account non-synchronous motors are more often styled "induction" motors. Being without exciter there is no commutator to keep in repair, though in the case of large size motors contact rings are sometimes used for the purpose of putting resistance into the armature circuit.

The next point is the starting. To do work a synchronous motor must run in step with the generator, and until it attains a speed such that its frequency corresponds with that of the generator; in other words, until synchronising speed is obtained, it is not in a condition to take the load. To run the motor up to speed various plans have been adopted. The exciter furnishes us probably with the most simple means of starting a single-phase motor. Though giving a direct current, the exciter will, of course, run as a motor if supplied with an alternating current, provided its field magnets are properly laminated. To start the synchronous motor, all we have to do then is to first turn the alternating current on to the exciter to get the speed up, then when it is obtained switch it on to the alternator, by the same action altering the connections so that the exciter afterwards performs the function of energising the field. Here I wish you to notice that though the synchronous motor will do no work by itself until it gets into synchronism with the generator, there is no reason why the motor and exciter combined should not do some work. It depends upon the size of the exciter and what margin of power it has beyond driving the alternator up to speed. Another plan is to combine with the exciter a set of secondary cells so that the energy necessary to start the motor by direct current is always available. During working hours the exciter is charging the battery. Polyphase synchronous motors can be started by a small induction motor provided for the purpose, or they may be designed so that currents induced in the field magnet by the action of the rotating armature field will pull the speed up to synchronism. Such currents might be generated in the masses of an unlaminated field magnet, or in copper loops properly disposed on the magnets. Of course, the combining of a secondary battery with the exciter works as well in the case of polyphase as single phase motors, and no further starting gear is requisite.

But induction motors have this advantage over synchronous motors, that they will start without any trouble at full torque. There are many notable instances of power transmission schemes being successfully operated by synchronous motors and with single phase currents, but the system lacks range and flexibility. If the whole of the power is to be given up by a single motor or group of motors at the delivery end of the line, single phase transmission with synchronous motors is, perhaps, as simple and reliable as any, but if the power has to be divided amongst a number of motors of various sizes, situated at different parts, and each requiring to be capable of starting against a load without extraneous assistance, single-phase working is no longer suitable. Under these circumstances, induction motors fulfil best the requirements of power distribution, and the attribute which singles them out as superior to other types is that they start without trouble, and, in starting, exert great effort. Polyphase working becomes necessary for them, as only with currents of more than one phase have the starting difficulties been entirely got over.

With regard to constancy of speed, the synchronous motor has the advantage, as it runs absolutely in synchronism with the generator, but there are few cases in which the variation in speed between no load and full load in properly designed induction motors cannot be permitted. Again, though in the matter of power factor the synchronous motor has the advantage, there is no doubt that for general work, taken all round, the induction motor is much superior, its great starting effort and extreme simplicity easily outweighing what advantages are possessed by motors of the synchronous class.

The chief qualities which should characterise a good polyphase induction motor are these:—

1. The speed should vary as little as possible with change of load.
2. The effort exerted at starting should be large, and that without drawing an excessive current from the line.
3. The efficiency, *i.e.*, the ratio of power given out to power put in, should be high.
4. The light load current should be as small as possible compared with the full load current.
5. The power factor should be as large as possible.
6. It should stand overloading to a considerable extent without pulling up.

Great attention has been bestowed on these points by several designers. As regards the first, the increase in speed due to throwing off all the load does not in well-designed motors of large size

Table III.—Size of Conductor required for Various Currents.

Gauge, S.W.G.	Diameter inches.	Sectional area. Square inches.	Resistance in ohms per mile at 60° F.	Weight lbs. per mile.	Amperes which the conductors will carry at a current density of									
					2,000 amps. per sq. in.	1,500 amps. per sq. in.	1,000 amps. per sq. in.	800 amps. per sq. in.	700 amps. per sq. in.	600 amps. per sq. in.	500 amps. per sq. in.	400 amps. per sq. in.	300 amps. per sq. in.	200 amps. per sq. in.
37/15	·504	·1541	·2892	3142·	308	231·	154·	123·	108·	92·5	77·0	61·6	46 2	30·8
19/13	·460	·1282	·3462	2625·	256·	192·	128·	102·	89 7	76 9	64·1	51·3	38 5	25·6
37/16	·448	·1219	·3661	2482·	244·	183·	122·	97 5	85·3	73·1	60·9	48·8	36·6	24·4
19/14	·400	·0973	·4579	1985·	195·	146·	97·3	77·8	68·1	58·4	48·6	38·9	29·2	19 5
0	·324	·0824	·5223	1678·	165·	123·	82·4	65·9	57·7	49·4	41·2	32 9	24 7	16 5
19/15	·360	·0789	·5652	1608·	157·	118·	78 9	63 1	55 2	47·3	39 4	31·5	23·7	15·8
1	·300	·0707	·6092	1438·	141·	106·	70 7	56 6	49·5	42 4	35·3	28·3	21·2	14·1
19/16	·320	·0624	·7154	1270·	125·	93 6	62·4	49·9	43 7	37·4	31·2	24·9	18·7	12·5
2	·276	·0598	·7197	1217·	119·	89 7	59·8	47·8	41·9	35·9	29 9	23·9	17 9	12 0
3	·252	·0499	·8633	1015·	99 8	74·8	49·9	39 9	34·9	29 9	24·9	19 9	15·0	10·0
19/17	·280	·0479	·9300	973·	95·8	74·8	47·9	38 3	33·5	28·7	23·9	19 2	14 4	9·6
4	·232	·0423	1 0186	860·	84·6	63 4	42 3	33·8	29 6	25·4	21·1	16·9	12 7	8·5
7/14	·140	·0356	1·253	727·	71·2	53 4	35·6	28·5	24·9	21 4	17 8	14·2	10·7	7·1
5	·212	·9353	1·253	718·	70·6	52 9	35 3	28 2	24·7	21·2	17·6	14·1	10 6	7·0
19/18	·240	·0349	1·271	715·	69·8	52·3	34·9	27·9	24·4	20 9	17·4	13 9	10·5	7·0
6	·192	·0289	1·487	589·	57·8	43 3	28·9	23 1	20·2	17 3	14·4	11·5	8·7	5·8
7/15	·216	·0289	1 543	589·	57·8	43·3	28 9	23·1	20·2	17·3	14·4	11·5	8 7	5·8
7	·176	·0243	1 770	495·	48·6	36·4	24 3	19·4	17·0	14·6	12 1	9 7	7 3	4·9
19/19	·200	·0243	1·831	496·	41 6	36 4	24·3	19·4	17·0	14·6	12·1	9·7	7·3	4 9
7/16	·192	·0229	1·953	465·	45 8	34·3	22 9	18·3	16·0	13 7	11·4	9·1	6·9	4·6
8	·160	·0201	2·142	409·	40·2	30·1	20·1	16·1	14·1	12·1	10 0	8 0	6·0	4 0
19/20	·180	·0198	2·261	402·	39·6	29·7	19 8	15 8	13·9	11·9	9 9	7·9	5·9	4 0
7/17	·168	·0174	2·552	356·	34 8	26·1	17·4	13·9	12 2	10 4	8 7	6·9	5 2	3·5
9	·144	·0162	2·664	331·	32 4	24·3	16·2	12·9	11 3	9 7	8·1	6·5	4 9	3·2
10	·128	·0128	3 346	262·	25·6	19 2	12·8	10·2	9 0	7 7	6·4	5 1	3 8	2·6

exceed 3 per cent. with constant voltage supply, while in the case of small motors it is only 6 per cent. A 100 H.P. motor would comply with the former figure, while a 5 H.P. would about comply with the latter. With respect to uniformity of speed, it will be observed that polyphase induction motors are quite on a par with the best direct-current motors. In both the speed is, of course, reduced when loaded by just such amount as will permit the current necessary to balance the load to flow through the armature.

As regards the second point, it is important that the current drawn from the lines be not too great at starting. For small motors up to 5 or 6 H.P. a short-circuited rotor, or squirrel cage winding as it is sometimes called, is only necessary, the excess of current at starting in the majority of cases not making much difference to the total current flowing. Such a rotor has an extremely small resistance, and when at rest it is to all intents and purposes the equivalent of a transformer with a short circuited secondary. It would, consequently, never do for large motors to have such armatures on account of the enormous currents which would flow through the conductors and the correspondingly large currents drawn from the line at starting. When we come to sizes above 8 or 10 horse-power, the armature bars are generally grouped in such a manner as to allow of a resistance being inserted into the rotor circuit at starting in much the same way as a resistance is inserted in the armature circuit of a direct current motor. For this purpose the conductors are arranged in series of three, and are connected starwise to a common junction, with their free ends brought to three insulated rings on the shaft. This is supplemented by a set of three resistance coils, also connected starwise, and with their free ends terminating in brushes resting on the insulating rings. The resistances are provided with a regulating switch operating all three branches at the same time, and thus the resistance inserted in the armature circuit at starting can be gradually taken out as the motor gets up speed. Apart from the resistance preventing an excess of current at starting, it has also the effect of increasing the starting torque, as excessive currents flowing in the rotor conductors weaken the resultant field and throw it greatly out of phase with the impressed field. By using a resistance in this way, then we can start against full running torque without drawing more than the normal running current from the line, while with twice the normal current we can get twice the torque. Here, again, the reduction motor is quite on all fours with direct current motors.

The efficiency of polyphase motors, the third point referred to, is about the same as that of direct current motors The following figures give some idea of the efficiency which makers are prepared to guarantee for various sizes at the usual speeds and frequency:—

H.P.	Efficiency per cent.
1½	76
4	80
5	80
12	84
15	88
50	91
110	92

I now come to a point which is of considerable importance, and that is the power factor or ratio of actual watts to apparent watts given to the motors. I have already spoken of motors behaving to some extent like choking coils, and it will be obvious that running light, a motor is nothing more than a transformer running on open circuit, a transformer, too, with an air gap in its magnetic circuit and requiring a large magnetising current relatively to the bulk of iron it contains. Now, in this kind of transformer the apparent watts (or product of current and difference of potentials) given to it are very different from the real watts, and in a polyphase induction motor, say, of 50 H.P., the former may be as an ordinary thing when running light 10 times as great as the latter. It results, therefore, that the current flowing in the circuit when the motor is running without load is comparatively large, and it actually reaches from 20 to 30 per cent. of the full load current. This current lags behind the impressed E.M.F. and does not indicate that the efficiency of the motor is low; it may, in fact, be analysed and regarded as two separate currents, one of which is pushed forward until it is in phase with the E.M.F., while the other is pushed backward until it lags 90° behind the E.M.F. The product of the first current and impressed E.M.F. gives the watts actually put into the motor, the second being 90° out of phase with the E.M.F. is a "wattless" or "idle" current. So much, then, for the power factor of motors running light.

(To be continued.)

WHISTLING ARCS.—A CASE OF ELECTRO-STATIC INDUCTION, AND THE REMEDY.*

By FORÉE BAIN.

During last summer the writer had under supervision the installation of a electric arc light plant designed for lighting the West Chicago parks and boulevards. The plant has an ultimate capacity of 1,350 full arc lights, the present number installed being 816, included in six circuits of about 400,000 feet of lead-covered, underground rubber wire cables. The size of the conductor is a trifle larger than No. 5 B and S. gauge. These cables are drawn into wooden pump log conduits placed in the grass plats along the boulevards and parks, about 12 inches below the surface. The lead cables are drawn into the poles in succession and are connected to the lamp switches in the pole base. From the switch wire of a similar character without lead covering extends to the lamp on the upper end of the pole. The pole is made in three sections, the lower base section of cast-iron and the middle section of a hollow wooden mast, while the upper iron section is a cast-iron socket around a goose neck of bent wrought-iron pipe, at the extreme end of which the lamp is attached by means of a lamp insulator.

Circuits No. 1 and No. 2 were the first that were completed and gave most of the trouble. Circuit No. 1 contains about 12 miles of cable and 116 Adams-Bagnall shunt arc lamps. Circuit No. 2 contains about seven miles of cable and 86 similar lamps. The district here referred to is designated in the diagram, fig. 8.

The strange phenomenon to which I refer was a loud harsh, whistling noise produced in the lamps as soon as the arcs were struck. The whistle was nearly identical in tone to that of the deviline whistle of the familiar peanut roaster. It registered somewhere between upper and middle C. It was very loud and could be heard about two blocks distant from the lamp engaged in this disagreeable pastime.

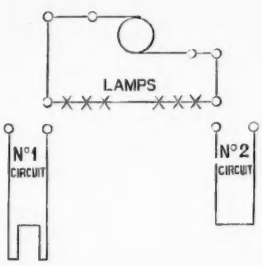


Fig. 1.

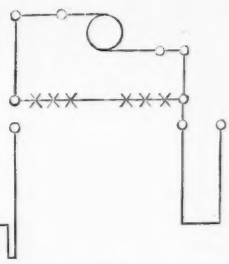


Fig. 2.

The lamps did not all whistle at one time, it seemed to be produced in those having long arcs. As soon as the lamp would feed, the whistling would disappear until the arc became long again, or this effect may have produced long arcs. It was noticed that the whistling was always accompanied by a flaming arc.

Before I had recovered from my surprise at this combination of light and music, the telephone and fire-alarm people were on the still hunt for the disturber of their peace. The telephone system of the entire west side of Chicago was rendered almost inoperative each day after 5 p.m. by this unusual induction. The noise in the telephone circuits was constant, and harsh as long as the plant was in operation and rendered the use of this little instrument of communication an abomination. It was very much the worst case of induction in the experience of the Chicago Telephone Company, and the management was naturally very anxious to find it and to remove the cause as quickly as possible. To their engineers, Mr. Abbott and Mr. Bentley, I am indebted for intelligent assistance; the latter gentleman recorded the result of the experiments and observations by agreement,

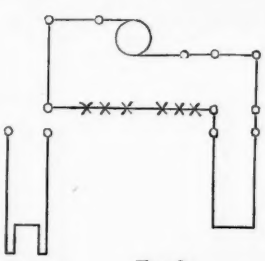


Fig. 3.

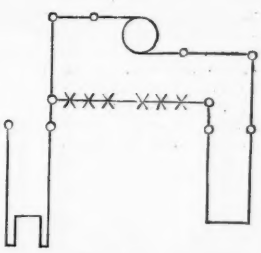


Fig. 4.

and from these records I have freely made extracts. I am also indebted to Mr. Adams of the Adams-Bagnall Company, L. E. Jones, my assistant and others. The first thought suggested was that the impulses due to the sections in the commutator set up vibration in the circuit, and that this caused the induction in the telephone circuit. This was proven fallacious by the use of different dynamos having commutators with a great difference in the number of segments. The Excelsior dynamo with 48 sections at a speed of 700 revolutions per minute would produce

$$\frac{48}{2} \times 700 = 16{,}800$$

impulses per minute. The Fuller-Wood dynamo with 175 sections at a speed of 900 revolutions per minute would produce

$$\frac{175}{2} \times 900 = 78{,}750$$

impulses. The tone in the lamps and in the telephone circuits was exactly the same pitch independent of the number of vibrations produced by the commutator of either dynamo. Had this been the producing cause the pitch would have been very decidedly changed. It was then thought that it might be a characteristic of the lamp; the armature being in motion might set up a counter electromotive force

* *Western Electrician.*

that would produce the effect in the arcs. It was found, however, on close examination that the armature of any given lamp was in a state of rest while its arc was whistling vigorously. It was thought that the infinitesimal motions of the armature of the lamp might produce vibration, but this was disproved by attaching two carbons over the top edge of a small pine box and separating them, when in circuit, by hand. The arc produced in this way could be made to whistle when the arc was lengthened and stop whistling when the arc was shortened.

Before the latter experiment was tried it was thought that probably the partially enclosed globe might be responsible, by holding the non-combustible gases which might in some way cause a vibration in the arc. The globe pans were opened so that the gases might drop out without any change in result.

The dynamos of the station are driven by means of the American system of ropes, and the usual static effect produced when leather belts are used is not present. Ropes are used partly for this reason. However, the frames of the dynamos were first grounded through a lead-pencil mark about 6 inches long and afterward through Geissler tubes, without any appreciable effect. Up to this time the whistling sound had been continuous as long as one or more circuits were in operation. When two circuits were started the induction of the telephone lines seemed to increase in volume with a slight change in the pitch of the note, probably the resultant of the two different notes. There were nodes in the new note that seemed to bear some relation to the hum of the dynamos, but of a very much higher pitch than that which was produced by the commutators and brushes of the Excelsior dynamos.

The lead sheaths of the cables were now metallically connected together at a point where they enter the dynamo room, and they were also grounded at 25 different places along the line of the circuits by means of long iron rods driven deep into the bottom of the manhole. After this was done it was noticed that the whistling would disappear and reappear at periods varying in duration and irregular intervals. Frequently the telephone circuits would be quiet for an hour and then in periods of only a few moments at a time.

A telephone receiver and several hundred feet of wire were taken out on the circuits to make tests. The first test consisted in stringing a single circuit between two electric light poles in Garfield Park, using the lamp poles as grounds.

The cables in Garfield Park are fibre cables that were put in about three years ago. The greater number of lamps on this circuit are of the Fuller-Wood double carbon type, and they were operated from the same dynamos as the other circuits.

No induction from this electric light circuit was noticed in this test, although the exploring line used was placed parallel to and in as close proximity to the circuit as possible between the poles.

The next station for test was upon the south side of Washington Boulevard, and about three lamps east of Homan Avenue, on the new rubber cable circuits. The first consisted in a repetition of the conditions at Garfield Park, the exploring wire being approximately 150 feet in length.

Gas lamp posts were also used for grounds, although it was found that there was no noticeable difference when gas and gas, gas and electric, or electric and electric posts were used for the test. This test showed a very perceptible induction in the exploring circuit of the same note and character as that noticed in the power house previously.

Then the exploring wire was stretched across the street at right angles to the circuits, grounds being obtained on either side through the gas and electric light poles. Induction was still very heavy, though probably not so much as in the former test. The exploring wire was moved to an angle of about 45 degrees to the line of the cables, when the induction was about the same as before. These experiments were repeated by touching the wire to the ground at either end, and here the induction was perceptible, but not so pronounced. The next test consisted in opening the manholes diagonally across the street and upon opposite sides, and connecting the sheaths of two cables of different circuits together through the telephone

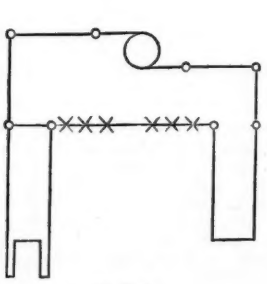


Fig. 5.

receiver. This test gave the same note, but so loud that it could be heard easily more than 100 feet away from the telephone. The telephone receiver was now taken out of circuit and the two lead sheaths were metallically connected together with the copper wire. It was noticed that when using the receiver without any wires being connected to it, and when the observer was stationed in the middle of the street, the induction was decreased when the metallic connection was made and louder when the connection was broken. Opening and closing was readily detected by the telephone. When the observer was outside of the area enclosed between the two circuits, this opening and closing of metallic connection between the sheaths made no perceptible difference.

Tests were now made in the vicinity of the cables with a receiver not connected in any way. This test showed that invariably when the axis of the telephone magnet was parallel to the plane of rotation of the lines of magnetic force and at right angles to the axis of the conductor, the induction was at its maximum when in comparatively close proximity to the cables, say 10 feet. The inductive effect on the telephone receiver was entirely neutralised when the magnet was either parallel to the plane of rotation of the lines of magnetic force and normal to the axis of the conductor, or normal to the plane of rotation of the lines of magnetic force and parallel to the axis of the conductor.

After these tests were made the writer became convinced that the trouble was caused by electrostatic induction, and it immediately occurred to him to join together the entire system of lead sheaths metallically wherever they had been severed, as when entering a pole, and this would have been done immediately but for the fact that nearly every foot of the lead sheaths was grounded by being in contact with damp tubes. They were virtually, it was thought, connected together, and, therefore, the idea of doing this was abandoned.

A great number of other tests were made using condensers, Leyden jars, exploring coils, Geissler, and Crookes tubes. An electrostatic voltmeter was used in measuring the potential of the circuits; several comparatively short pieces of cable, probably several 100 feet in length, used to connect the dynamos to the switchboard, were connected together by attaching a wire to the sheaths of each piece and joining these together. The potential between these lead sheaths and ground was found to be 250 volts, something more than a volt per foot. At this discovery it was thought by several of the observers that it was leak and not induction. To determine this point a 220 volt 16 candle power incandescent lamp was connected in between the sheaths and ground, and the filament turned a bright red. If it had been a leak the lamp would probably have glowed above normal candle power. A 16 candle power 110 volt lamp was substituted and the heating of the filament was just barely visible, indicating that the static capacity of the cable was exhausted with the flow of a very small current. When a telephone receiver was substituted for the lamp the whistle was very loud and could be heard all over the power house above the noise of the machinery.

Geissler tubes were then used. Circuit No. 1, which had evinced the most decided results was selected. Several tubes were made and placed at intervals of about one mile apart on the circuit. These tubes were of a low exhaustion and were connected between the copper

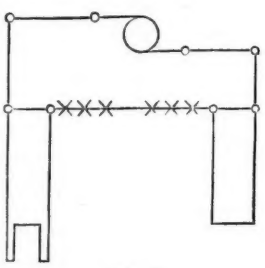


Fig. 7.

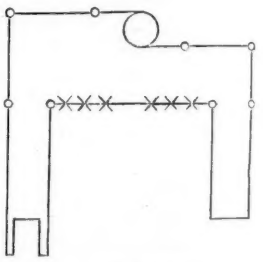


Fig. 6.

conductor and the lead sheaths. For about two hours after these tubes were placed in circuit, after the lamps were lighted, it was noticed that all induction ceased and the telephone circuits for the first time were unaffected. It was observed that some of the tubes were discharging and illuminating the entire interior of the lamp poles in which they were placed, while several others seemed to be entirely inoperative. The result of this experiment was to have all of the tubes shattered after being in service less than three hours. Tubes of different sizes and of different degrees of exhaustion, from a Geissler to a Crookes, were tried, with the result that when the exhaustion was low enough to effect any change in the induction the tube would soon become destroyed, and when the exhaustion was high enough for durability its effect to reduce the induction could not be noticed, therefore, the use of tubes was abandoned.

The next experiment consisted in connecting up 100 lamps in the station, arranged at the switchboard so that any desired combination of this lamp circuit with any of the external circuits could be made. All lamps upon circuits Nos. 1 and 2 had been cut out, leaving simply the ohmic resistance of the copper conductor in the circuit.

Fig 1. illustrates the first test. This consists simply in starting 100 arcs in the station without any external connection. These lamps started off without trouble and no trouble was noticed on the telephone lines.

The second experiment, as shown by fig. 2, consisted in legging on to one side of the lamp circuit in the station, one side of No. 2 circuit. With this arrangement no trouble was experienced in starting the lamps and no noise could be heard upon the telephone lines.

Fig. 3 shows the third experiment. This consisted simply in looping circuit No. 2 into the lamp circuit at the station. No trouble was experienced in starting the lamps and no noise resulted.

Experiment No. 4, fig. 4, consisted in legging on one side of circuit No. 1, as shown in the sketch, No. 2, circuit remaining exactly the same as in test No. 3. With this arrangement the old trouble was

noticed in starting the load. The machine flashed over a number of times. The circuit was finally started by cutting off the external circuits, and after the circuit was placed in operation these external circuits were plugged on as shown. A very troublesome note was immediately noticed upon the telephone system. This was practically the same in volume as had been noticed previously.

Test No. 5, fig. 5, consisted in looping in both circuits Nos. 1 and 2, upon the lamp circuit at the station. The note was increased slightly in volume.

Test No. 6, fig. 6, consisted simply in short-circuiting circuits 1 and 2, at the power station, leaving the closed loop so formed tapped upon each side of the machine. With this arrangement the volume of inductive trouble increased to the greatest degree that had ever been noticed. It was so bad that telephones absolutely could not be used and business was practically suspended on the telephone lines for about five minutes during which the test was in progress.

In test No. 7, fig. 7, the connections were the same as in the last test, with the exception that the jumper was taken off circuit No. 2, cutting the circuit in series. These are the only different combinations which were made with the circuits.

An interesting experiment performed in the station with conditions favourable for the inductive trouble was the drawing of an arc in a box between two plain carbon points. This arc was drawn and developed exactly the same singing that had been noticed in the lamps.

The experiment was also made between two pieces of copper wire. In the latter case the arc was particularly noisy. This, of course, indicates that the arc itself is one particular feature of the trouble. In all probability it would seem that it was caused by the whistling arc and the capacity of the underground cables.

boulevard, upon the east side of Ashland Avenue. These latter practically short-circuited the loops upon Washington boulevard and Jackson boulevard east of Ashland Avenue.

A jumper was also put between the sheath of No. 1 circuit on the north side of Washington boulevard and the west side of Ashland Avenue, to the sheath of circuit No. 2 upon the south side of Washington boulevard and west side of Ashland Avenue, also another jumper from the sheath of circuit No. 2 on the north side of Jackson boulevard and the west side of Ashland Avenue to the sheath of circuit No. 1 on the south side of Jackson boulevard and west side of Ashland Avenue. These jumpers were placed in service rather hurriedly and probably not as perfect workmanship was put upon them as though more time had been allowed. The result, however, of the test was extremely satisfactory. Induction was practically removed, but as a very faint trace remained and as it was supposed that improved connections and the consequent decrease in resistance would further remedy the trouble, this was tried and proved to be true. The jumpers were securely soldered together, and now that the plant is operating at nearly its full capacity there is absolutely no noise observed in the lamps or on the telephone system.

A very peculiar phenomenon was observed when a very great difference of potential was impressed between two circuits, that is that the static charge would short circuit over the commutator of the dynamo and cause it to "spill over" before it could "pick up" to more than six amperes, and when a circuit was attached to both poles of the dynamo feeding 100 lamps in the station, this effect was so pronounced as to render it impossible to start the lamps until the circuits had been first entirely cut loose from the lamp circuit and afterward plugged in when the dynamo had picked the lamps up.

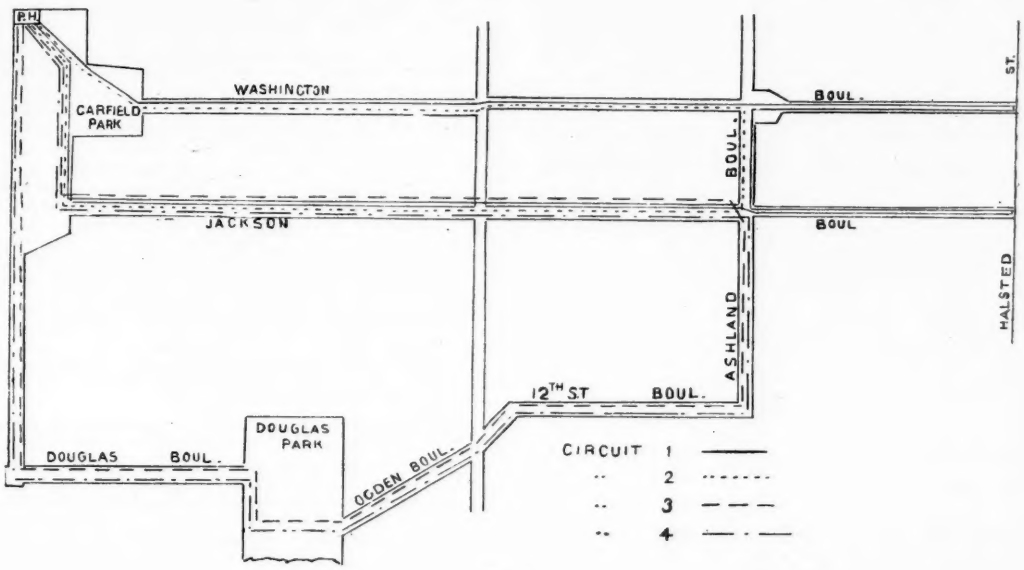


Fig. 8.

It will be noticed in looking over the diagrams submitted herewith, that in no case was trouble noticed except where a difference of potential existed in the underground system. Where a test circuit was simply carried on one of the external circuits the difference in potential was very small, being only that due to the ohmic drop in the conductor.

When one circuit was upon one side of the load, the other being upon the opposite, and the maximum difference of potential existing, the note was increased in volume, as would be expected.

Putting the jumpers upon the circuits, as in experiment No. 6, simply raises the potential upon all points of the circuit to the maximum, and the resulting very loud note is what would be expected.

In making an experiment in the station of drawing the arc by hand, it was noticed that the pitch of the note remained unchanged for variations in the length of the arc. This would indicate that the capacity of the cable is the ruling factor which governs the pitch. Whistling was, of course, noticed in the arcs upon the test circuit in the station. The whistling seemed to travel from point to point upon the circuit, there being approximately one-third of the lamps singing at the same time. It would seem that when a lamp or set of lamps fed, thereby shortening their arcs, the note was immediately taken up by another lamp, or other lamps.

As a result of these experiments it was decided to interconnect, as far as possible, the sheaths of the underground cable, the idea being that thereby the difference of potential which had necessarily existed in different pieces of the sheath would then be decreased. Jumpers were put on between the sheaths of the two pieces of cable entering each manhole. In addition a jumper was put from sheath to sheath on the north and south sides of Washington boulevard and Jackson

The foregoing experiments and observations seem to lead to the following conclusions:

The phenomenon is entirely independent of the type of dynamo or lamp used.

It is the characteristic of a cable having a high dielectric and large static capacity.

It is to a very great degree independent of the insulation resistance of the circuit to ground as a whole.

The pitch or note produced is determined by the average length of the lead sections left unconnected in a given circuit.

Atmospheric conditions do not in the least affect it. The whistling was as noticeable and pronounced on the dampest night as when the thermometer indicated 20 degrees below zero.

The effect of metallically connecting all the lead sheaths together neutralises or removes the static charge. There was no perceptible static charge left in the cable after the current from the dynamos ceased to flow.

That the reason the flashing of a dynamo carrying high voltage does not effect to pierce a cable is because self-induction and static induction never allow the potential to rise above the initial, and, therefore, inherently the cables protect themselves.

The only difference in the installation of these circuits and that of usual practice is that in these circuits the cables from the manholes to the lamp poles pass through separate ducts for convenience, and the lead sheaths do not come into intimate metallic contact. In most other cases they are brought into metallic contact by being brought together in the came duct.

The static effect seemed to decrease the power factor of the dynamos without altering their operating efficiency. However, this was not accurately determined.

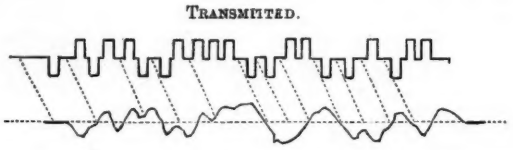
MODERN VIEWS OF ELECTRICITY.

We extract the following from a pamphlet reprinted from the *Proceedings* of the American Philosophical Society entitled "The Insulating Medium Surrounding a Conductor the Real Path of its Current," by Professor Edwin J. Houston and Dr. A E. Kennelly. Their exposition of modern views as to the manner in which an electric current is transmitted through insulated conductors is remarkably lucid considering the rather abstruse nature of the question, and will certainly assist the electrical world to obtain a clearer idea of what is now generally considered to be the accepted theory.

We hope to deal more fully with this present day contribution to electro-technical literature at a future date, in the meanwhile we place before our readers the authors' views on the transmission of signals through submarine cables together with our comments on the matter, which will be found on another page of this issue:—

"According to these views, therefore, the electric current, which is electric flux rush, is invariably transmitted with the velocity of light in the ether of the particular insulator considered. But the actual velocity with which an electric impulse travels along the circuit, as measured by the time which elapses between the connection of the source at the generating end, and the appearance of energy at the receiving end, always tends to be less than this velocity, because, owing to attenuation and distortion, the first impulse or block of flux may be completely absorbed and dissipated before it can reach the distant end with the velocity at which it travels, and further flux must gradually come up from the source and suffer attenuation and distortion, before the vanguard can finally arrive at the receiving end and perform its allotted function. It is for this reason that a submarine electric cable between say Ireland and America, takes nearly $\frac{1}{7}$th of a second before an electric signal or impulse transmitted from one end will make its first appearance at the other, although the time that an electric wave would take to traverse its length would be only say about $\frac{1}{50}$th second. The original impulse travelled so far as it went with the velocity of light in the ether of gutta-percha, but the vanguard was completely dissipated and the successive vanguards were attenuated with complete dissipation for a comparatively long time before the distant end could be reached.

"It is only on long circuits, such as are afforded by telegraph and telephone wires or submarine cables, that the phenomena of electric transmission with their attendant distortion and attenuation are most clearly evidenced. In the comparatively short circuits employed for transmission of electric light and power, the phenomena of distortion and attenuation of electric and magnetic flux are of little practical importance. The fig. represents the signals sent over



Distortion of Signals Received Over Last-laid Atlantic Submarine Cable.

the last laid Atlantic cable and the corresponding signals which were received at the distant end. The two should be exact facsimiles and should, therefore, be capable of actual superposition if no distortion occurred in the electric impulses. Not only the delay or retardation in the received signals, but also the great distortion which is noticeable, are due entirely to the fact that there is very little leakage in the insulator, while there is very appreciable resistance in the conductor. This cable, laid in 1894, has a published length of 1847·5 nautical miles. The copper conductor offers a resistance of 1·68, or about 1⅔rds, ohms per nautical mile, while the insulator has a resistance of 85,000,000,000 ohms in each nautical mile. This cable has a working speed of over 45 words per minute, which is much faster than any other previously laid Atlantic cable, owing to the greater conductance of the circuit. This cable possesses, of course, enormous distortion, although such distortion does not prevent signals being read until a speed of over 225 letters per minute is attained. If, however, the insulation, instead of being 85,000,000,000 ohms in each nautical mile, were reduced to about 500 ohms in the nautical mile, the leakage tailings would probably balance the tailings due to imperfect conductance and the cable would be distortionless. The signals received would, therefore, be the exact counterpart of the signals sent, and an indefinitely high speed of signalling should be possible. In respect to absence from distortion, such an Atlantic cable would transmit telephonic speech waves perfectly. It would, however, possess so much leakage that the received signals would be far too attenuated and feeble to perceive. The conductor would only offer at the sending end a resistance of, approximately, 28 ohms, instead of 3,108 ohms, the total conductor resistance, and the current strength which would flow from the receiving end to ground would be, approximately, 5×10^{47} times less than the current entering at the generating end. No telegraphic or telephonic instrument at the present time could detect so feeble a current as this. Moreover, if any accident happened to such a cable it would be impossible to localise the position of the fault unless the same occurred within a mile or two of either end. Consequently, the distortionless circuit does not provide at the present time a practical solution for trans-Atlantic telephony. About 100 miles is probably the limiting length of this particular cable, with its good insulation, over which telephonic speech can be carried.

"We have not considered the mechanism whereby the electric and magnetic flux, when it reaches the receiving end, is absorbed and its energy utilised for the performance of any kind of work, such as the operation of a motor, the production of signals, or of articulate speech. It has been sufficient to point out that the electric current runs through the insulator from one end of the circuit to the other, and is guided by the two conductors, which, with the insulator, form the circuit. If it were not for these two conductors, any electric wave or impulse would radiate out into space in all directions, like light from an unprotected candle. The wires do for the electric wave what a reflector does for the search light; namely, localises and concentrates the beam into a single path, whereby it may be transmitted to the desired point with the minimum attendant loss in transmission."

NEW PATENTS AND ABSTRACTS OF PUBLISHED SPECIFICATIONS.

NEW PATENTS.—1897.

[*Compiled expressly for this journal by* W. P. Thompson & Co., *Electrical Patent Agents*, 322, *High Holborn*, *London*, *W.C.*, *to whom all inquiries should be addressed.*]

8,019. "Improvements in incandescent electric lamps." C. J. P. Robertson. Dated March 29th.

8,025. "Improvements in electrical connections for tables and the like." O. T. Banks. Dated March 29th.

8,036. "An improved power storage system and secondary motor for traction systems." A. C. Brown, G. R. Neilson, and E. Burn. Dated March 29th.

8,048. "A new or improved regulator for governing the pressure of electric circuits connected with primary or secondary batteries." L. W. Heath and J. H. Field. Dated March 29th.

8,059. "Improvements in elements for secondary batteries and electrodes for electrolysis." D. G. Fitzgerald. Dated March 29th.

8,070. "Improvements in and connected with electric signalling on railways." G. H. Clarkson. Dated March 29th.

8,092. "A method of and apparatus for preventing the sticking through leakage currents of electric railway section switches." F. C. Esmond. Dated March 29th.

8,095. "Improved construction of sockets or holders." A. J. Boult (Deutsche Elektricitats Aktien Gesellschaft, Germany.) Dated March 29th.

8,115. "An invention for facilitating the application of electric communication on railway trains." J. Taylor and J. Edward Duckworth. Dated March 30th.

8,131. "Improvements in primary electric batteries or generators." S. Van Buren Essick. Dated March 30th. (*Complete.*)

8,185. "Improvements relating to the generation and distribution of alternating electric currents for light and power." J. Wetter. (The Electricitats Aktiengesellschaft vormals Schuckert & Co., Germany.) Dated March 30th.

8,226. "A method of and apparatus for preventing the stickage through leakage currents of electric railway section switches." F. C. Esmond. Dated March 30th.

8,239. "An improved electricity meter for registering the amount of current consumed on direct or alternating polyphase, triphase, or quadruplephase circuits." F. J. Beaumont and F. Hallows. Dated March 30th.

8,277. "Improvements connected with electrical distribution." T. Cooper. Dated March 31st.

8,280. "Improvements in and relating to electro-medical apparatus and brushes for use therewith." C. Klein. Dated March 31st. (*Complete.*)

8,313. "Improvements in dynamo-electric machinery." F. W. Anderson. Dated March 31st.

8,350. "Improvements in or relating to electric contact makers and breakers." E. Perks. Dated April 1st.

8,416. "Improvements in electrical switches." W. J. Davy and G. T. Davies. Dated April 1st.

8,420. "A method and apparatus for preventing the sticking through leakage currents of electric railway section switches." C. S. Drummond. Dated April 1st.

8,438. "Improvements in arc lamps." R. Hurry and O. Coxwalker. Dated April 2nd.

8,442. "An electromagnetic tempering apparatus." J. McKay. Dated April 2nd.

8,537. "Improvements in or connected with electric batteries." H. Stanhope. Dated April 2nd.

8,554. "Improvements in or connected with electric batteries." H. Stanhope. Dated April 3rd.

8,554. "Improvements in electrical switches." W. Durant, and T. W. B. Durant. Dated April 3rd.

8,563. "Improvements in connection with submarine cable laying appliances." C. S. Snell. Dated April 3rd.

8,588. "Improvements in electrical resistance apparatus." H. H. Mavor, W. A. Coulson, and S. Mavor. Dated April 3rd. (*Complete.*)